MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

VOLUME 59 NUMBER 9

Contents for September, 1937

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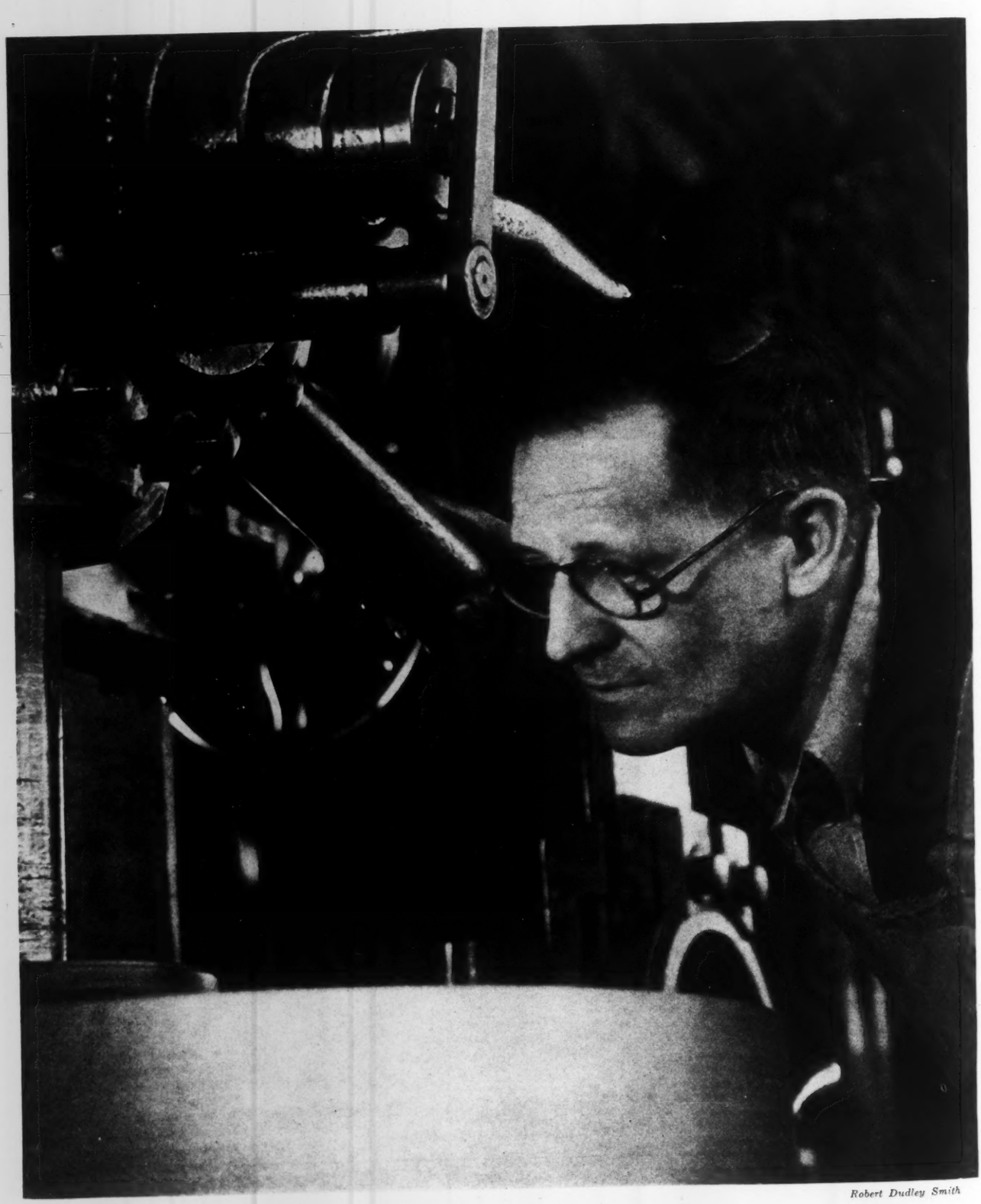

Robert Dudley Smith

Man and Machine Are One

VOLUME 59
No. 9

MECHANICAL ENGINEERING

SEPTEMBER
1937

GEORGE A. STETSON, *Editor*

After the Whistle Blows

RUMOR has it that it was at the insistence of Willis R. Whitney, sage of the General Electric research laboratories, that a section on hobbies of members and associates was included in the 1200-page "Sigma Xi Half Century Record and History." The society in 1936 had about 36,000 members on its rolls and there is no simple way of determining how many confessed to one or more hobbies, but the list contains about 380 items of ways in which those who did report amuse themselves after the whistle blows. It is a fascinating and somewhat astounding list and some comments on it may throw light on the habits of scientific folk.

It is said (the story may be apocryphal) that this same Dr. Whitney was surprised one day to find that a dining-car waiter had served him a bottle of white rock. To clear himself of trifling with Dr. Whitney's diet the waiter offered the order check in testimony. It seems that Dr. Whitney, absentmindedly imagining himself to be at his club, had set his signature to the check and the waiter had interpreted this as an order for white rock. However this may be, Dr. Whitney does not claim "writing" as a hobby, although, as his friends will guess, he admits interest in arrowheads and turtles. Just why a scientist whose days are spent peering into the future should concern himself with vestiges of ancient cultures and survivors of the reptilian age can be explained only on the theory of opposites.

That not all scientists choose their hobbies on this theory is shown by the fact that a rough classification of the 380 listings shows about half are concerned with pure and applied science, evidence of that real zest for the job that knows little distinction between work and play. Yet play there is, as 28 listings under sports of various kinds, with golf (266 addicts), bridge (25), chess (20), fishing (more than 200), and a variety of others will prove. Photography carries off the honors with nearly eight columns of names (about 75 to the column) followed by music with five columns, gardening three, and stamps two.

But to continue the more general classifications, it was found that what may be called cultural avocations have 20 entries, those relating to the family and other social contacts 25, art 31, agriculture and gardening 26, and interest in animals and insects 16. A host of other entries difficult to classify generally runs the gamut of human recreational and intellectual pastimes and interests too numerous to mention.

Certain oddities lead one to wonder if the scientists are spoofing us. Is the interest of the person who chose arthritis subjective or objective? And whence comes "budgets" as a hobby? There is something refreshingly normal about the woman whose hobby is cats (Persian), and worldly about the two members who admitted "dancing," even though one qualified it by adding "artistic." Hats off to him who "likes to do things others say can't be done," to another whose hobby is "trying to understand life," to the man who confesses that he indulges in "pipe dreams," and to the lone protagonist for "thinking." Two A.S.M.E. members admitted to an interest in "power production," and another (he lives in Hartford, Conn.) set down "machine tools." Engineering got two votes, Diesel engines one, air-conditioning two, automobiles seven, engines three, hydraulics two, industrial contacts one, invention three, lead soldiers (honest fellow!) one, and machinery, metals, models (mostly boats and railroads), woodwork and wood turning quite a few.

It would be interesting to drop in on these scientists and share their enthusiasms with them for they are probably "regular fellows" after the whistle blows.

A Smaller World

TEN YEARS after Lindbergh made his spectacular solo flight across the North Atlantic, commercial airplanes began a series of experimental trips preparatory to the establishment of a regular commercial service between two continents.

Significant as this new venture appears to be, it yields place in the imagination to the two successful flights by aviators of the U.S.S.R. across the uncharted North Pole ice cap from Moscow to California. Girdling the earth from East to West has engaged men's attention since the days of Columbus and the merchant adventurers, but to go west by flying north is a new and bold attempt to shatter distance and imagined isolation.

Sponsored by the Institute of the Aeronautical Sciences in cooperation with the Aeronautical Chamber of Commerce of America, the American Geographical Society, The American Society of Mechanical Engineers, the Explorers Club, and the National Aeronautic Association, a meeting was held in the Engineering Auditorium, New York, N. Y., on July 29, to greet the men who made the record-breaking flight from Moscow to California—6262 miles in 62 hr and 2 min. Mikhail Gromoff, chief pilot, who was to have delivered a lecture, was absent because of illness, but Andrei Yumosheff,

copilot, and Sergei Danilin, navigator, looking quite unromantic in summer white, represented him.

Down in front a couple of young men from a broadcasting station went through the business of introducing the aviators to the vast audience of a national network and to an international audience, via short wave, so that the world might hear, and the people back home in Russia learn from the lips of their own airmen, and in their native language, the story of the adventure. In a world made so small by aviation and the radio, what international possibilities cannot be imagined?

And so this is the beginning of no one knows what. It is something more than another triumph of aviation. It is a real factor in international affairs, one of those impacts of science that readjusts human relationships. It reaffirms confidence in airplanes, engines, and aviators. Like Lindbergh's flight it opens up the possibilities of new trade and transportation routes. It holds the promise, if men use it rightly, of the better understanding of each other by peoples in widely separated parts of the world. May men so use it!

How the "Thirty-Fivers" Feel

AFTER a member of The American Society of Mechanical Engineers has paid dues for thirty-five years he is exempt for life from further payment. When he completes this thirty-five year period a letter of notification is sent him by the Council and with it goes a "permanent" membership card, printed on gold pasteboard.

Members who have attained this status of "permanent" membership are justly proud, and, in many cases, surprised when they receive the letter of notification and the gold card. Their letters of acknowledgment reflect grateful appreciation and not infrequently contain protestations of loyalty and affection for the Society. Many of them bear testimony to the particular ways in which the Society has been of benefit and of what association with it has meant in individual cases. Opportunity for service in Society work, with the privilege of forming personal and professional friendships highly prized, is frequently mentioned as greatest of the benefits derived from a thirty-five year membership. To read these sincere expressions of appreciation and goodwill brings a realization of the vital influence that a professional society has been able to exert in the lives of some of its members. One of the richest and most gratifying fruits of long-continued associations, this warmly cordial affection of men for an institution to which they have contributed much more than their dues is indeed something to be prized.

After all, a professional engineering society is what its members make it. Because of them and their communal efforts it acquires a distinctive personality and spirit which each member interprets differently, perhaps, but which all who have served it faithfully feel to be a very real thing. It is an asset which cannot be entered upon a financial balance sheet.

Foreseeing Effects of Inventions

FEW PERSONS are likely to have the time or inclination to read the 450,000-word report of the National Resources Committee's subcommittee on "Technological Trends and National Policy," released on July 18. The press carried releases based on the foreword and introductory chapters, and comments on the proposal to set up a federal committee responsible "for keeping abreast of technological changes and for forecasting imminent changes that may affect national life." For the benefit of readers of MECHANICAL ENGINEERING, Ralph E. Flanders, past-president of The American Society of Mechanical Engineers, is preparing a comprehensive review of the report which will be published as soon as it is available.

Awareness to everyday trends is most certainly desirable and we cannot make too many earnest attempts to understand the significance of present-day events. To forecast the impacts of science and technology on society should have profitable results for humanity as well as individuals and relieve future generations of much trial and hardship. Whether or not it can be done will best be determined by an attempt to do it; but most of us, will have more to quarrel about as a result of the way in which a committee might seek to exercise control than its endeavors to acquire a knowledge of facts upon which controls could be based.

The trouble, it seems, has its seat in man's inventions which are claimed to be disturbing to economic balance and social stability. Witness any great invention as a case in point, and try to evaluate the good and evil that have sprung from it. Here the cautious man demurs from assuming the responsibility of forecasting. He thinks of Faraday and the induced current, of Eli Whitney and the cotton gin, of Edison and the incandescent lamp, of the late Marconi and the radio, of the Wright Brothers and the airplane.

Undoubtedly, as portions of the report testify, the distinguished persons who prepared the report are realistic enough to recognize the size of the task they set up for the proposed committee. Whether such a committee would be a help or a hindrance remains to be seen, as does the probability that their advice would be heeded by legislators and enterprisers. Trial of the proposal should be made only under the most rigid safeguards to future progress and individual initiative. Although all intelligent persons will agree that a reasonable looking ahead is sound insurance against disaster, they are also likely to concur with Mr. Kettering who says that no man ever stumbles while standing still.

Because of their intimate concern with inventions and their development, engineers have a personal as well as a general stake in the success of planning the development and control of technological progress. If such planning is to be attempted, engineers should be given a place at the council board, and, if they are given that place, they will have to develop that sense of social responsibility and insight for human needs without which technological laissez faire is to be preferred.

THE ELECTRIC GAGE

By C. M. HATHAWAY and E. S. LEE

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AN ELECTRIC gage is a device for measuring linear dimensions or displacement by electricity and particularly for accurately measuring either small dimensions or small variations in larger dimensions. According to this use of the term the electric gage does not contain within itself some fundamental standard of length and hence differs in this respect from some optical gages that measure small displacements in terms of the wave length of light. The electric gage requires calibration from master standards of length and can be used after calibration for the measurement of all dimensions within its calibrated range.

Usefulness of this gage to the mechanical arts and the mechanical engineer lies partly in the fact that the minuteness of the motions which can be measured has almost no limit. Displacements as small as 0.00001 in. or even 0.000001 in. can be read on an electric indicating instrument. Mechanical amplification ratio, defined as the ratio of motion of the indicator to displacement under measurement, can be easily made as high as 10,000 or 100,000 or even higher if desired, and high amplification ratios can be obtained without introducing frictional effects, such as hysteresis or sticking. Additional characteristics that contribute to the value of this gage are the high accuracy with which measurements can be made, and the fact that displacements under measurement can be indicated or recorded with electrical instruments at any distance from the gage itself.

Various forms have found extensive use for inspection of finished products and measurement of their dimensions, continuous measurement of strip and sheet thickness during manufacture, measuring strain in mechanical parts under either static or high-speed transient loading, and many other problems involving mechanical measurements of widely different types.

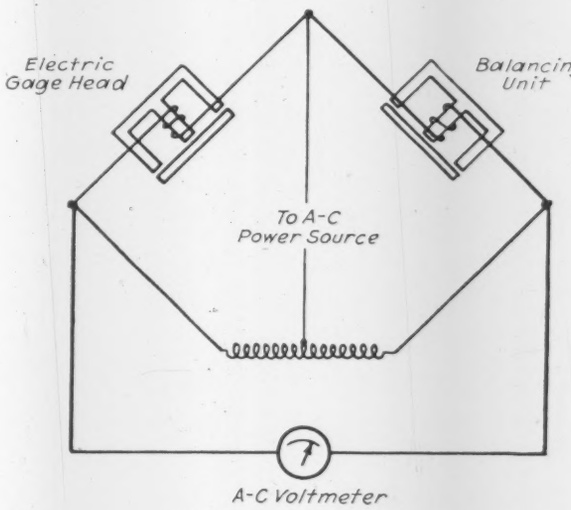


FIG. 1 FUNDAMENTAL CIRCUIT DIAGRAM OF BRIDGE-TYPE ELECTRIC GAGE

PRINCIPLES OF OPERATION

According to our usage of the term, the electric gage is fundamentally a device by which an electric current is controlled or modulated according to the relative position of two of its parts. This relationship between current and displacement can be brought about in several ways. Variations in resistance, capacitance, inductance, or wave form can be produced by variations in linear dimensions, and these can be measured by variations in an electric current. Several methods of electric gaging will be described which are interesting either because of historical background or value to a particularly interesting application. These are (*a*) capacitance, (*b*) bridge, (*c*) saturation, and (*d*) eddy current.

The first method is interesting because of abundant references to it in the literature and because it represents some of the first attempts to measure mechanical displacements by electricity. The bridge method is particularly applicable to most gaging problems, the saturation method is frequently desirable where unusually low contact pressure on the part being gaged is desired, and the eddy-current method is mentioned because it has solved a particularly difficult gaging problem.

The capacitance method deserves attention chiefly because of its historical interest. Fundamentally, this method depends on the fact that the capacitance of a parallel-plate capacitor is a function of the distance between the plates, so that if one of them is fixed and the other is allowed to move with the displacement to be measured, its value can be measured by the change in capacitance of the capacitor.

Inasmuch as total capacitance is small, measurements are always made at high frequency, which is most conveniently obtained from a small vacuum-tube oscillator. In some methods of measuring the capacitance change the variable capacitor is made an element in an "LC" oscillatory circuit, so that capacitance changes will cause changes in frequency of oscillation. The change resulting when one capacitor plate is moved can be measured by comparing the frequency of oscillation with that of another oscillator operating at a constant frequency. In this way small changes in frequency can be detected.

Another method is to couple the oscillatory circuit consisting of the variable capacitance and an inductance loosely to a high-frequency oscillator. If the circuit is tuned nearly but not exactly in resonance with the oscillator, small changes in tuning such as would be caused by corresponding variations in the plate separation will produce large changes in the energy absorbed from the oscillator. These can be determined by measuring the current in the oscillatory circuit or the oscillator's output. In general, electric gaging methods involving measurement of capacitance changes are not as applicable as other simpler ones, particularly for use outside the laboratory because numerous constants that must be maintained to a high degree of accuracy render permanent calibration difficult.

The second method employs a simple Wheatstone bridge with iron-core reactors that contain air gaps in two of its arms. The air gap in one core is fixed, while that in the other is caused to change with the displacement being measured. An alternative scheme is to allow one air gap to increase as the other decreases. A diagram of the fundamental circuit is presented in

Contributed by the Machine Shop Practice and Railroad Divisions for presentation at the Fall Meeting, Erie, Pa., Oct. 4–6, 1937, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Fig. 1. An alternating voltage of a frequency determined by the particular requirements is applied across two arms of the bridge and a sensitive alternating-current instrument is connected across the other two arms. When both air gaps are equal the bridge is balanced and the instrument indicates zero. An increase or a decrease in either air gap will unbalance the bridge and cause an indication.

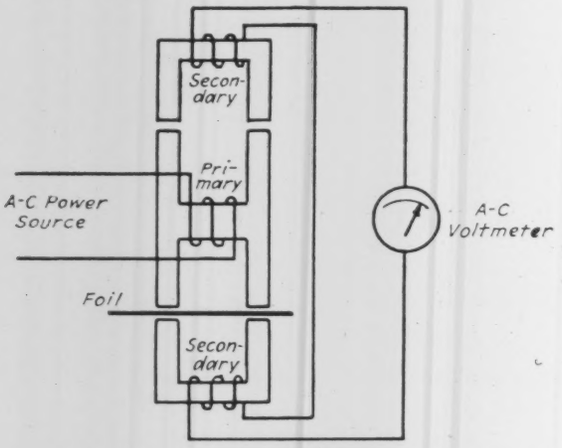


FIG. 2 ARRANGEMENT OF CIRCUITS IN AN EDDY-CURRENT TYPE GAGE FOR MEASURING FOIL THICKNESS

Unbalance of the bridge by motion of the armature in the electric gage head is caused by several factors. One would suspect that the major cause of unbalance if the two air gaps were unequal would be the difference in reactance of the two bridge arms, but actually other factors contributing to the unbalance are sometimes of even greater importance. Change in the air gap varies the iron loss in the pole tips and armature, thus changing the effective resistance of the coil, and this contributes to unbalance. Changes in flux density resulting from variations in the air gap alter the wave form of the exciting current, producing a harmonic unbalance that also contributes to the instrument indication, so that contributing to the instrument deflection are (*a*) change of inductance, (*b*) change of effective resistance, (*c*) shifting of phase, and (*d*) harmonic unbalance. All of these can be magnified by proper design so that surprising sensitivities can be obtained without using amplifiers to increase the bridge output.

The bridge-type gage has several desirable characteristics that have made it particularly applicable to a wide range of problems. The circuit is simple, comprising the minimum number of simple parts. Adequate sensitivity and output can be obtained for practically all requirements without auxiliary amplifiers. Except for measuring transients having steep wave fronts, only a 60-cycle power supply is required. Circuit elements are sturdy and compact and of a type that can be made constant in characteristics so that gages of this type exhibit unusual freedom from drift and will preserve calibration for a long time.

One factor contributing to unbalance of the bridge-type gage is a change in wave form resulting from a change of flux density in the pole tips and armature. Electric gages utilizing this effect alone have been designed and the method is referred to here as the saturation method because the effect depends on the drooping characteristic of the saturation curve. In one gage of this type, an iron vane or armature is pivoted at one end and the other end is movable between the poles of a permanent magnet so that the vane will carry no flux when its free end is midway between the poles. If the free end is moved nearer one pole than the other, some flux from the magnet will traverse the vane, around which a coil that is excited from an alternating-current source is wound. When the vane carries flux from the permanent magnet, the exciting current will be distorted and unsymmetrical, that is, it will contain both odd and even harmonics, and because of the latter the positive loop of the current wave will not be of the same shape as the negative. These harmonics can be measured and an indication of the motion of the vane's free end thus obtained. An interesting method of measuring the even harmonics is to connect a Thyrite resistor, whose resistance decreases with increasing current, in series with the exciting coil. When an unsymmetrical current wave is passed through such a resistor, a direct-current voltage component will appear across it. A direct-current instrument is, therefore, connected across the resistor and a filter to keep the alternating current out is placed in series with the instrument.

This gage is simple and capable of sufficient sensitivity and power output for many applications. Its chief advantage lies in the fact that low contact pressures can be obtained, making it particularly suitable for some applications where this is a requirement.

The eddy-current method is applicable to measuring the thickness of nonmagnetic metallic sheets, particularly thin foils which must be measured without touching the material. A sheet is placed with its plane at right angles to the lines of force in an alternating magnetic field. Eddy currents are induced in the sheet and the value of these currents can be measured by their effect on the field, which is proportional to the thickness of the sheet. Fig. 2 shows the arrangement of circuits in an eddy-current gage for measuring thin foils which uses a transformer having two flux paths, each with a secondary winding. In each path is an air gap of equal length, and when the secondary coils are connected in series with their volt-

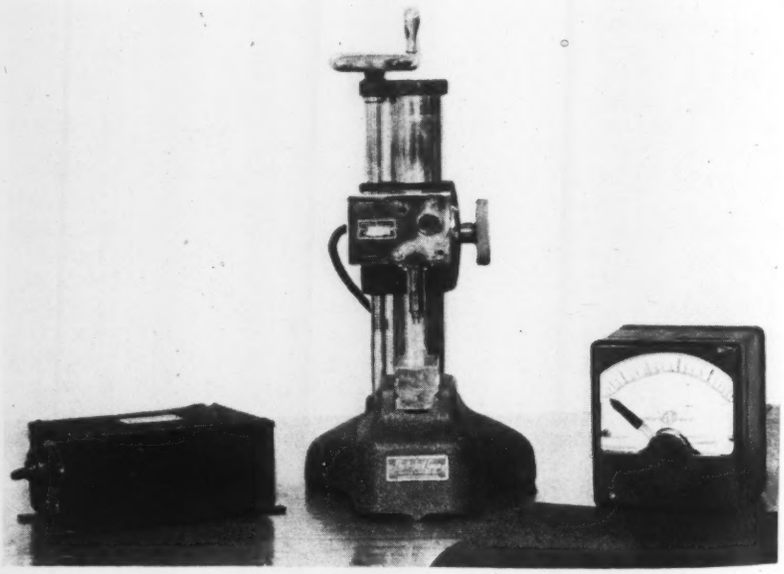


FIG. 3 ELECTROLIMIT COMPARATOR GAGE AND ASSOCIATED EQUIPMENT
(From left to right, they are power unit, gage, and indicating instrument.)

ages opposed, the net secondary voltage applied to the instrument is zero. If a piece of foil is placed in the lower air gap, eddy currents induced in the foil will tend to prevent the passage of flux. This magnetic path will now carry less flux than the other, less voltage will be induced in the lower coil than in the upper, and a net voltage that is a function of the foil thickness will appear across the instrument. The instrument indication is also proportional to the specific resistance of the material, which is a function of temperature, so that if temperature variations are too great, some form of temperature compensation must be added.

APPLICATIONS FOR INSPECTION

The bridge-type gage is particularly applicable as an inspection gage for measuring finished-parts dimensions. For such uses the electric gage possesses many advantages over "go and no-go" gages as much greater accuracies are possible, less skill is required in their use, and finished parts can be graded for matching in assembly. Another advantage in quantity production is its adaptability to multiple-gage stands so that a number of dimensions can be read simultaneously. Long life of gage parts and permanence of calibration have also contributed to the value of the gage in this field of measurement.

An electric gage head of the bridge type, designed particularly

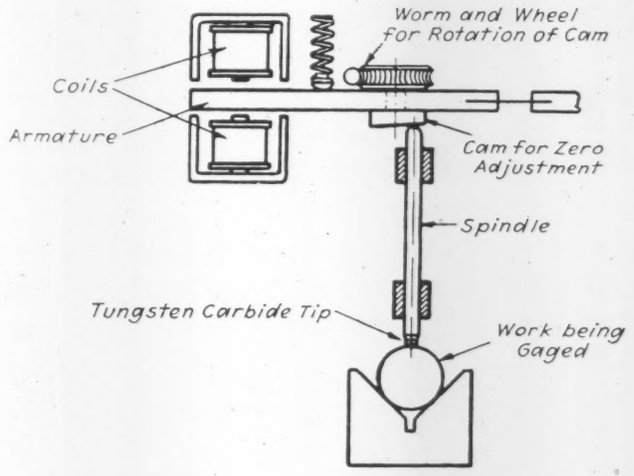


FIG. 4 SCHEMATIC DIAGRAM OF THE ELECTROLIMIT COMPARATOR GAGE

for use as a comparator in inspecting and measuring finished parts, is shown in Fig. 3 mounted on a comparator stand with its power unit and indicating instrument. It is of the type widely known as the Electrolimit gage and contains an armature consisting of a steel bar pivoted at one end by a flat steel spring. The free end of the armature moves between two coil structures and increases the air gap on one side and decreases that on the other. The armature is moved by a spindle sliding in lapped bearings and having one end bearing against the work, as shown in the diagram, Fig. 4. A cam located between the armature and the spindle and rotated by a worm provides a delicate zero adjustment by regulating the position of the armature between the two coil structures. The power unit contains a transformer, a voltage regulator, a reactor, and a rectifier, so that gage head, power unit, and indicating instrument constitute one complete unit.

Fig. 5 illustrates the adaptability of the gage head for simultaneous measurement of four dimensions of a crankpin. On the instruments shown, a 1-in. deflection of the pointer corresponds to 0.0001 in. on the part being measured. By dividing the scale graduations into ten parts the dimensions can be read consistently to 0.00001 in. without noticeable frictional hysteresis. As reading closer than 0.0001 in. usually is not necessary, the intermediate graduations are frequently omitted.

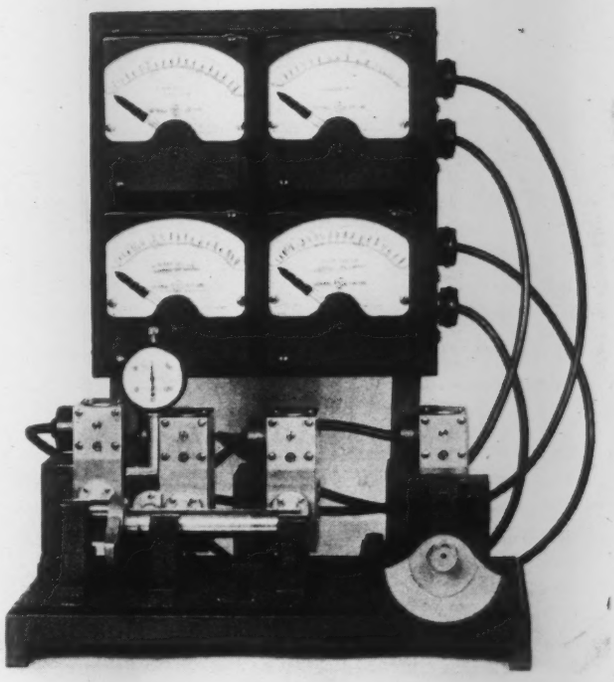


FIG. 5 MULTIPLE-GAGE STAND ARRANGED TO MEASURE FOUR DIMENSIONS OF A CRANKPIN

(A variation of 0.0001 in. on the piece being measured produces a movement of 1 in. on the indicating instruments. By dividing the scale graduations into ten parts, readings of 0.00001 in. can be obtained consistently without noticeable frictional hysteresis.)

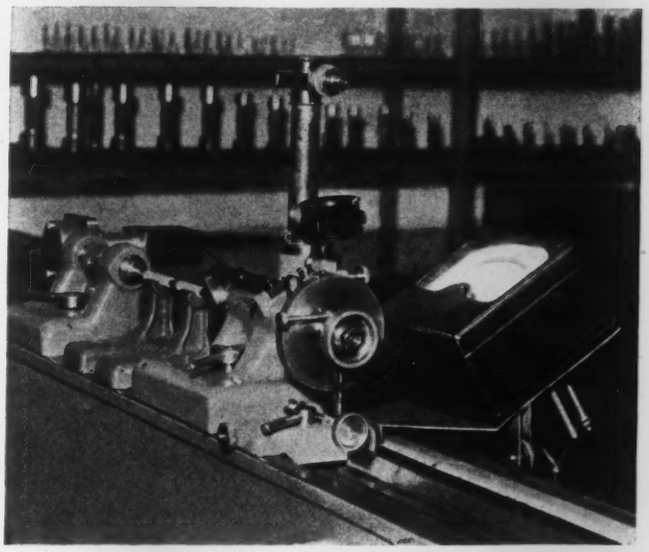


FIG. 6 ELECTRIC GAGE MOUNTED ON THE TAILSTOCK OF A PRATT & WHITNEY MEASURING MACHINE TO INDICATE POSITION OF THE SPINDLE

An interesting application of the electric gage has been made

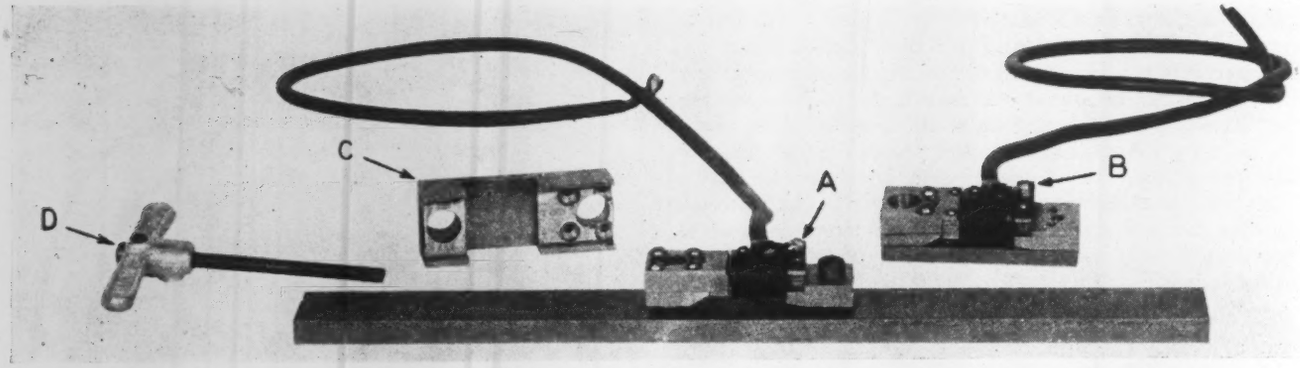


FIG. 7 GAGE CAPABLE OF MEASURING STRAINS AS LOW AS 0.00001 IN. IN A GAGE LENGTH OF $2^1/_4$ IN.

(*A* is the gage mounted on a bar that is being tested; *B* is the balancing unit, *C* is the jig used for mounting the gage; and *D* is the wrench. This gage weighs only $4^3/_4$ oz.)

to the tailstock of a Pratt & Whitney measuring machine and is shown in Fig. 6. Using this gage to indicate the spindle's position has facilitated operation of the machine and comparison work possessing a higher degree of accuracy than formerly is now possible.

STRESS AND STRAIN MEASUREMENTS

An application that is of specific interest to the mechanical engineer is measurement of stress and strain in structural members and machine parts subjected to either static or transient loading. For this work, the bridge-type gage is pre-eminently suitable because it can be made small, can be subjected to high accelerations, can measure transient strains having a wave front of 0.001 sec or less under most adverse conditions, can be calibrated on a testing machine and then transferred to the member that is to be tested without any loss of accuracy, and will maintain this calibration with great accuracy for a long time.

In a recent series of tests, 22 strain gages were used on various members of three different locomotives over a period of two months. They were calibrated before, during, and after the tests, and throughout the entire time only one gage was found to be out of calibration, and that to the extent of only 0.00005 in.

An electric-strain-gage head and its balancing unit is shown in Fig. 7. The element *A* that is mounted on the member under test is termed the gage head and a similar element. *B*, for insertion in the other arm of the bridge circuit is termed the balancing unit. This is similar in electrical characteristics to the gage head, so that when the air gaps of the two are equal, the bridge is balanced. Both gage head and balancing unit are provided with a cam for adjustment of the air gap. The former weighs $4^3/_4$ oz and is mounted on the member to be tested by two $^1/_4$-in. machine screws spaced $2^1/_4$ in. apart. Strains as low as 0.00001 in. in the $2^1/_4$-in. gage length could be measured with this gage if desired. On steel, with a modulus of 30,000,000, this corresponds to a stress of only 133 lb per sq in. Such sensitivities are seldom desired, and this capacity is mentioned merely to indicate that extremely high sensitivities are possible.

The characteristic of the electric strain gage by which it can be calibrated on a testing machine and then transferred to the member to be tested without any change in the calibration is important as it is particularly responsible for general application of this gage to precision testing. Sensitivity of the strain gage depends on the length of air gap, hence if this is the same after the gage has been applied as it was on the testing machine, the sensitivity would not have changed by the transfer. Mechanical measurement of this gap to the requisite degree of accuracy would be practically impossible, but fortunately it can be done accurately by the strain gage itself, in the following manner. When the gage is set up on the testing machine, the bridge circuit is balanced by the air-gap adjustment on the balancing unit until the instrument reads zero. The balancing-unit adjustment is then locked and calibration made. After the gage has been transferred to the member to be tested, the air gap of the gage head is adjusted until the instrument again reads zero. Since the balancing unit has not been changed, the air gap of the gage head is the same as during calibration to a sufficiently high degree of accuracy to cause no error in reading the instrument.

Strain gages are being used with success for measuring pressure exerted on the rolls of a steel mill. For this application

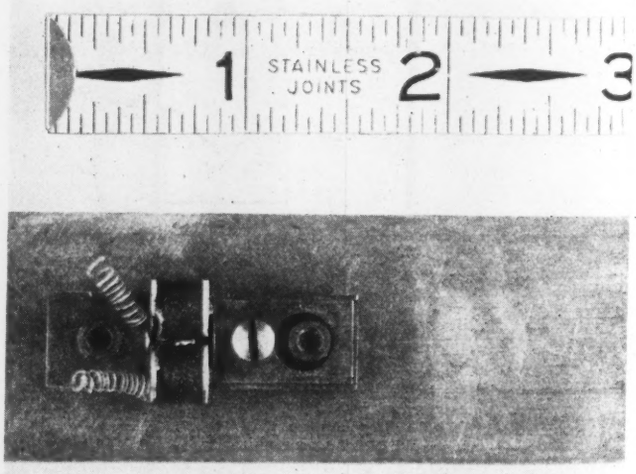


FIG. 8 AN EVEN SMALLER ELECTRIC STRAIN GAGE MOUNTED ON A STEEL BAR $1^1/_4$ IN. WIDE

(This gage is similar to that illustrated in Fig. 7 except for size. The gage length is 1 in. and the weight is only $^1/_2$ oz.)

the Electrolimit gage head has been used. It is mounted on one side of the mill stand so as to measure stretch over a portion of the stand when load is applied. As unit stress in this part of the mill-stand casting is low, elongation over a 14-in. length is measured. In this way pressure applied to the rolls can be either indicated or recorded or both indicated and

recorded simultaneously at any desired distance from the mill stand.

For applications requiring a smaller strain gage, that shown in Fig. 8 can be used. It is similar to the larger one except in size, having a gage length of 1 in. This head weighs $^1/_2$ oz and is attached either by two 8-32 machine screws spaced 1 in. apart or by clamps. An amplifier is included in the power unit of this small gage so that a sensitivity which equals that of the larger one is obtained.

For static or slowly varying strains, an indicating instrument that is calibrated directly in either stress or strain is employed, and 60-cycle power supply can be used. For recording rapidly varying strains, an oscillograph replaces the indicating instrument, and a time-strain record is obtained on a moving strip of sensitized film or paper. A 2000-cycle power supply can be used, thus permitting recording of transient strains having a wave front of 0.001 sec or less.

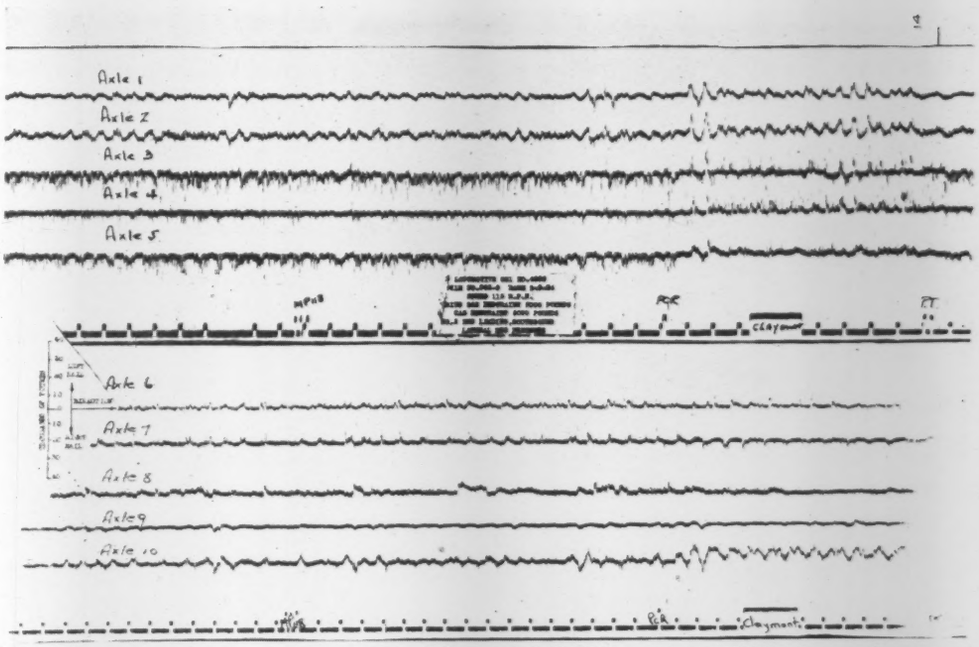
Fig. 9 is a record of four strains and two displacements made simultaneously on a six-element oscillograph using four strain gages. These records of stress in various bridge members during the passage of a high-speed locomotive were made by the Pennsylvania Railroad. Use of strain gages that were properly placed on the bridge structure enabled the railroad's engineers to

(1) Measure the dynamic stresses set up in the bridge members during the locomotive's passage.

(2) Study resonance behavior of the bridge members at different speeds.

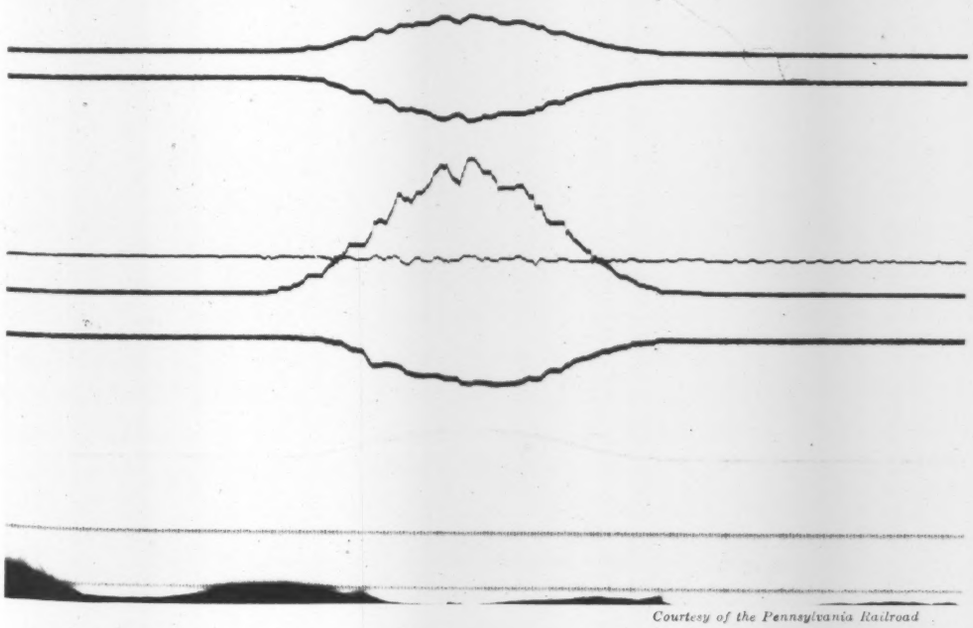
(3) Measure stresses in the structural formation which were too complex to permit ready calculation. These studies were of great value to the railroad in maintaining high-speed schedules safely.

Fig. 10 is an oscillogram of stresses in various axles of an electric locomotive during a high-speed test run and Fig. 11 shows one gage mounted on the weighbar of this locomotive for measurement of lateral forces on the axle.



Courtesy of the Pennsylvania Railroad

FIG. 10 OSCILLOGRAM OF STRESSES IN THE VARIOUS AXLES OF AN ELECTRIC LOCOMOTIVE DURING A HIGH-SPEED TEST RUN



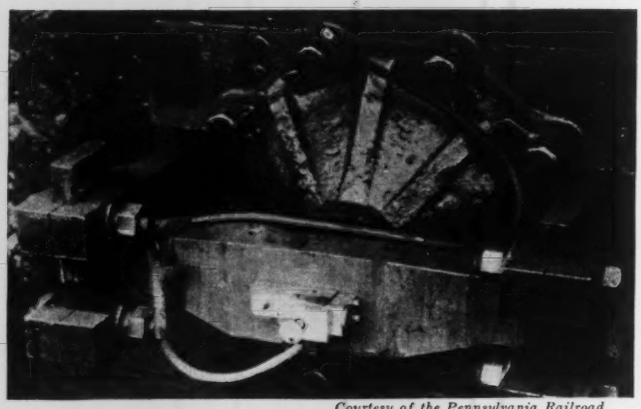
Courtesy of the Pennsylvania Railroad

FIG. 9 OSCILLOGRAPH RECORD OF STRAINS AND DISPLACEMENTS IN BRIDGE MEMBERS CAUSED BY THE PASSAGE OF A HIGH-SPEED LOCOMOTIVE

(Simultaneous records of four strains and two displacements were obtained with four strain gages and a six-element oscillograph.)

ENAMEL AND METAL-FOIL THICKNESS GAGES

A modified bridge-type gage has been found useful for measuring thickness of paint, enamel, and plating over flat steel surfaces. To do this a coil within an iron shell approximately 1 in. in diameter is placed on the



Courtesy of the Pennsylvania Railroad

FIG. 11 STRAIN GAGE MOUNTED ON AN ELECTRIC-LOCOMOTIVE WEIGHBAR

(This gage measured lateral forces acting on an axle in the test giving the results that are reproduced in Fig. 10.)

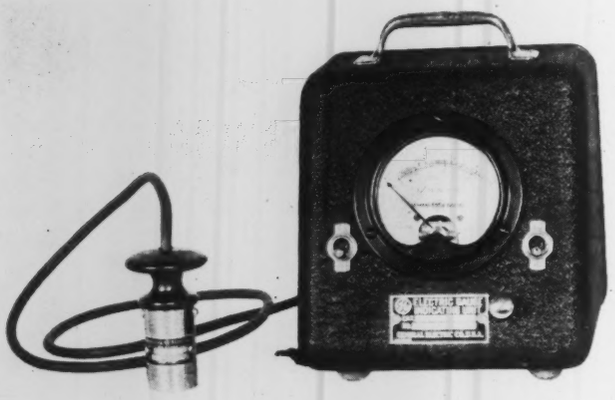


FIG. 12 GAGE FOR MEASURING THICKNESS OF AN ENAMEL FILM

(This gage is used for measuring the thickness of enamel, paint, and plating films on flat steel surfaces. Variations in film thickness produce corresponding changes in the impedance of the coil in the gage.)

surface, the paint or enamel forming an air gap between the pole tips and the steel backing. This coil is connected in one arm of the bridge and a fixed balancing coil in the other. Variations in the paint thickness cause variations in impedance of the gage coil, so that the indicating instrument can be calibrated in terms of paint thickness. An enamel-thickness gage is shown in Fig. 12.

A development of the eddy-current type of gage for continuous measurement of aluminum foil during rolling is illustrated in Fig. 13. To the right is shown the gage head having a gap $^3/_8$ in. wide through which the foil is passed. The indicating instrument is calibrated with zero at the center of the scale, so that, with foil of correct thickness in the gap, the pointer remains on zero. A variation in thickness of 0.0001 in. will cause the pointer to move to the right or the left depending on whether the foil is too thick or too thin. The instrument can be set to zero for any thickness of foil within the range of the gage. A 2000-cycle power supply is required for its operation.

SUMMARY

The term "electric gage" has been defined, and a number of forms that are of particular interest to the mechanical engineer have been described.

One form was shown to be of value in measurement and inspection of finished dimensions, particularly in large production when small tolerances must be maintained. The electric gage permits accurate fitting and matching of parts within the tolerance range; it has long life and maintains its calibration, and high magnification can be obtained without sticking.

Applications of the gage to strain measurement have been described. Gages that have proved of great value to the mechanical engineer as analytical instruments for the analysis of strain in loaded structures and machines have been illustrated. Factors contributing to the value of the strain gage for these uses are accuracy, small size, possibility of calibration on a testing machine before use, permanency of calibration, and the possibility of use with an oscillograph for obtaining permanent records of rapidly varying stresses.

Other applications of the electric gage have been described indicating the versatility of this device for many problems of mechanical measurement. The electric strain gage is particularly useful when (*a*) strains are very small, (*b*) measurements must be made with accuracy under adverse conditions, (*c*) gages must be subjected to high acceleration, (*d*) rapidly-varying strains must be measured, and (*e*) permanence of calibration is desired.

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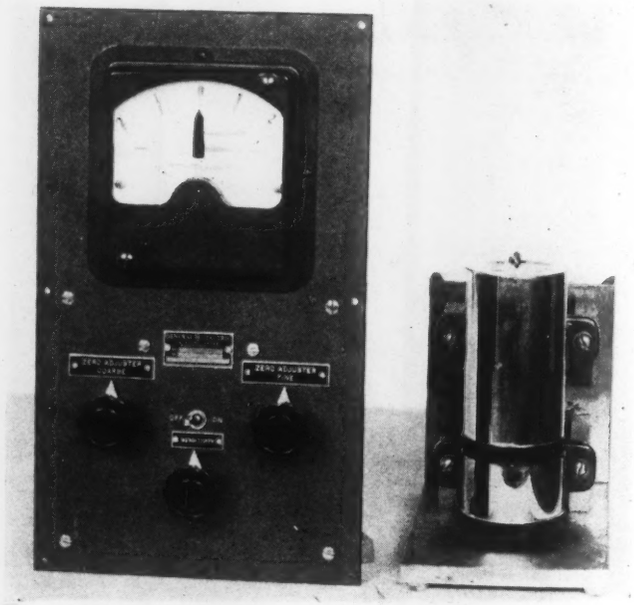

FIG. 13 GAGE FOR MEASURING THICKNESS OF ALUMINUM FOIL

(This gage is a development of the eddy-current type, for which a circuit diagram is shown in Fig. 2.)

U. S. Navy Participation in DIESEL-ENGINE DEVELOPMENT

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EFFICIENCY is a divine attribute and the foundation of every virtue in an engineer. The engine, now universally designated by the name of the originator of the idea to make the heat of compression ignite the fuel charge, is the result of a systematic search on his part for a more efficient way of converting the heat within the fuel into mechanical energy. In the forty years of its successful development no one worthy of the name of engineer challenged this principal claim of the Diesel engine that it represents the most efficient means of producing mechanical energy by combustion, i.e., more power can be produced out of a given weight of fuel oil in a Diesel engine than in any other way.

Other important advantages possessed by the Diesel engine from a naval engineer's point of view include

1 Ability to start quickly and develop full load in less than one minute, if necessary

2 Smokeless exhaust under all normal operating conditions, a great advantage for submarines and aircraft carriers

3 Economy in space required within the ship, particularly if the bulky boiler uptakes are taken into consideration

4 Weight per shaft horsepower comparing favorably with the best of the steam plants of equal reliability

5 Reliability equaling the proverbially reliable though far less economical types of steam plant

6 Availability far surpassing that of any steam plant as demonstrated by modern streamlined trains

7 Vulnerability far less than any steam plant, which at times requires high-pressure steam piping of excessive length, the latter proved to be a source of great danger in naval engagements of the World War

8 Adaptability to the propelling-plant requirements peculiar to a naval vessel

On the other hand, anyone even casually coming in contact with the combatant ships of the Navy is bound to be impressed by the tremendous efficiency of their propelling plants in weight and space required. Naval propelling plants, whatever their type, represent the highest development of the art consistent with the desired degree of reliability and life expectancy.

GERMANY LEADS IN DEVELOPING NAVAL DIESEL ENGINES

How far then did the navies of the world appreciate the Diesel engine and how much did the United States Navy contribute to its development, particularly within the last few years? This question is believed to be of interest to all engineers and the author will therefore attempt to throw some light on the subject even though a veil of secrecy must, for obvious reasons, hide the details of the picture as far as it concerns the recent Diesel-engine applications in the United States Navy.

When building of naval vessels was resumed in Germany the development of the modern high-speed, lightweight types of Diesel engine was not sufficiently advanced to permit their consideration for propelling plants of warships.[1] Not until after the three cruisers, *Königsberg*, *Karlsruhe* and *Köln*, were well under way did test results with an M.A.N. four-cycle, two-cylinder experimental unit, developing 100 bhp per cylinder at 1000 rpm and weighing 11 lb per hp, give sufficient promise to permit the installation of two 10-cylinder cruising units geared to the propeller shafts. A hydraulic clutch of the Foettinger type, interposed between the engine and its reduction gear, Fig. 1, permits the Diesel engine to be easily and reliably

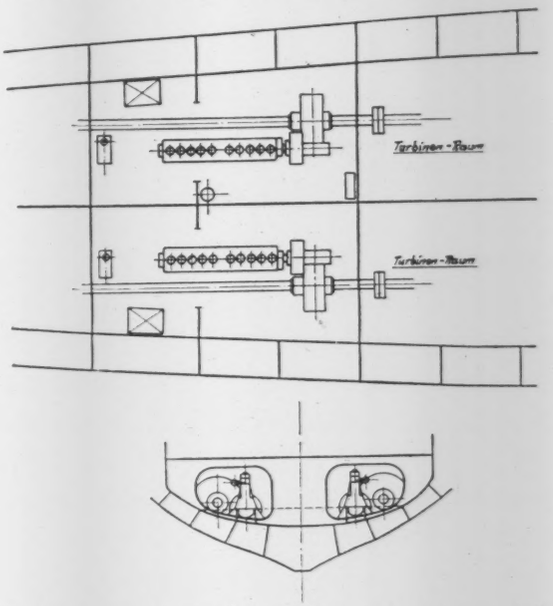

FIG. 1 CRUISING DIESEL PLANT OF THE GERMAN CRUISERS, *Königsberg*, *Karlsruhe*, AND *Köln*

disconnected when steam turbines are to be operated. These Diesel engines were thus installed for cruising only and must be carried as dead weight when steam turbines are in operation. To avoid excessive upkeep the rating of the Diesel engines had to be reduced later to 900 bhp at 900 rpm, which gave a ship speed of about 10 knots and a cruising radius of about 18,000 miles with all bunkers filled with Diesel oil.

These Diesel engines appear much too small to be of real value to the ship, since on long cruises foulness of the bottom reduces the ship's speed materially. Besides in wartime even on long cruises, a substantial part of the boiler plant must be kept under steam and the turbines warmed up if a reasonably quick

Presented at the Tenth National Oil and Gas Power Meeting, State College, Pa., Aug. 18–21, 1937, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Released for publication by the Bureau of Engineering, Navy Department.

[1] "Die Nachkriegsentwickelung des dieselmotorischen Schiffsantriebes in der Deutschen Marine," by W. Laudahn, Jahrbuch der Schiffbautechnischen Gesellschaft, vol. 32, 1932, pp. 110–141; also: "Jane's Fighting Ships," edited by F. E. McMurtrie; Sampson Low, Marston & Co., Ltd., London, 1936, pp. 242–243.

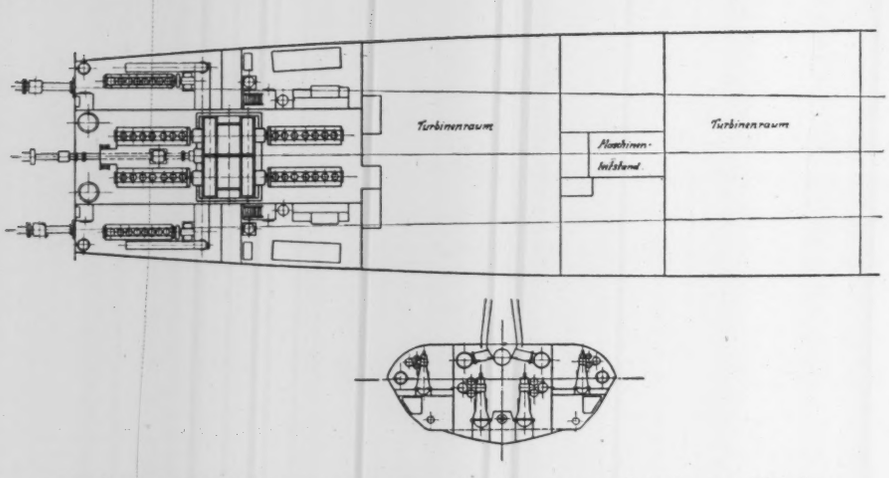

FIG. 2 CRUISING DIESEL PLANT OF THE GERMAN CRUISERS *Leipzig* AND *Nürnberg*

getaway is to be assured. The steam plant of these cruisers is designed for a maximum output of 60,000 shp.

German Cruisers Leipzig and Nürnberg

Meanwhile, the development by M.A.N. of a four-cylinder two-cycle double-acting experimental unit of 250 bhp per cylinder at 800 rpm and weighing only 6.6 lb per hp, without blower, permitted approaching the problem of including Diesel engines into a naval propelling plant from a different point of view. Therefore, in the cruiser *Leipzig*, although the 60,000 shp steam-turbine twin-screw plant was retained, no cruising turbines were provided and a 12,000-shp Diesel propelling unit was added to operate a separate propeller in the center, Fig. 2. Four Diesel engines were connected to a common reduction gear by hydraulic clutches and were designed to give the ship a cruising speed of 18 knots with the turbines disconnected and the wing screws driven with zero thrust by geared electric motors receiving their energy from a generator geared to the center shaft. To permit the Diesel plant to be used for propulsion when turbines were driving the wing screws a variable-pitch propeller was fitted to the center shaft. In addition to the four seven-cylinder propelling Diesel engines two auxiliary seven-cylinder Diesel units of smaller cylinder dimensions but also of two-cycle double-acting type were installed. These drive the scavenging blowers and circulating-water and lubricating-oil pumps as well as a starting air compressor. Later a similar plant was installed in the cruiser *Nürnberg*, which is substantially a sister ship of the *Leipzig*.

German Gunnery Training Ship Bremse

While in these two ships a composite propelling plant was employed, the next German warship to be built, the gunnery training ship *Bremse*, became the first completely Diesel-driven warship, excepting submarines of course. The principal reason for the adoption of a Diesel propelling plant was the fact that the exceedingly light construction of this vessel permitted no protection for steam piping from the boiler to the turbine, and an unprotected pipe carrying high-pressure, high-temperature steam is a source of real danger in a war vessel. A total of 26,000 shp in two four-engine geared units, using eight-cylinder engines of the same cylinder dimensions as those of the main engines in the *Leipzig*, was installed, Fig. 3.

For the four auxiliary engines driving scavenging blowers and pumps the same cylinder size was used but these units had only four cylinders and operated at lower speed.

Pocket Battleship Deutschland

The successful progress of the preceding program of Diesel-engine construction gave sufficient confidence in the feasibility of a still larger and more important propelling plant, so that a twin-screw 54,000-shp Diesel plant for the so-called pocket battleship formerly known as *Ersatz Preussen* and later christened *Deutschland* was decided upon. The plant consists as in the *Bremse* of two four-engine geared units using nine-cylinder engines of almost double the horsepower output per cylinder, a cylinder size which was meanwhile thoroughly tested out experimentally. The four auxiliary engines driving the scavenging blowers, as well as circulating-water and lubricating-oil pumps, consist of five-cylinder units of the same cylinder dimensions but with lower maximum speed—425 rpm. In addition,

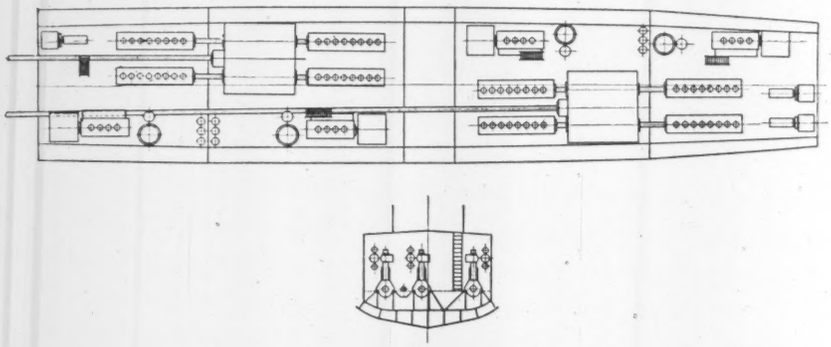

FIG. 3 DIESEL PROPELLING PLANT OF THE GERMAN GUNNERY TRAINING SHIP *Bremse*

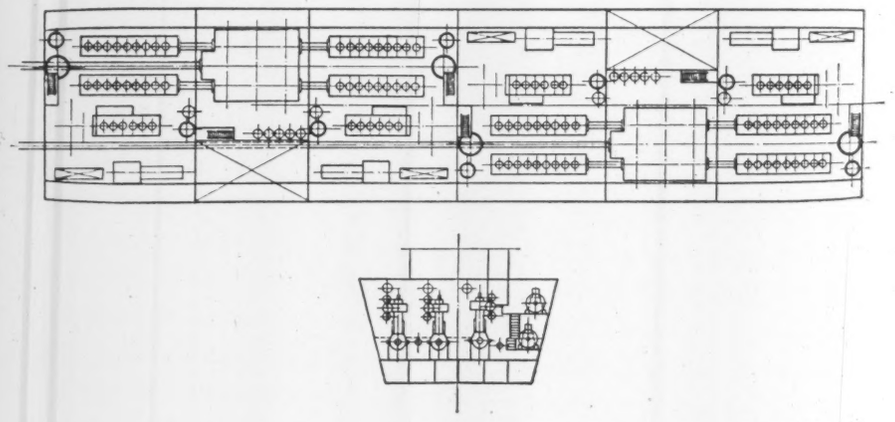

FIG. 4 DIESEL PROPELLING PLANT OF THE GERMAN POCKET BATTLESHIP *Deutschland*

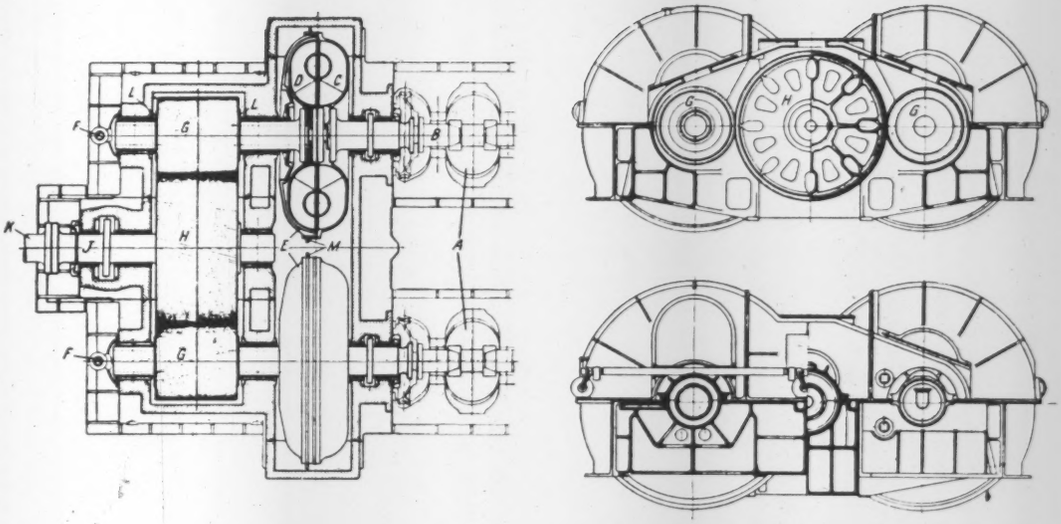

FIG. 6 GEAR DRIVE WITH HYDRAULIC COUPLINGS USED IN THE GERMAN NAVY

eight four-cycle Linke-Hoffman-Busch Diesel-driven generators of 250 kw each were installed, two in each engine room, to supply the ship's light and power needs. The general arrangement of the *Deutschland* propelling plant is shown in Fig. 4.

German Pocket Battleships

In the two sister ships of the *Deutschland*, *Admiral Scheer*, formerly the *Ersatz Lothringen*, and *Admiral Graf Spee*, the propelling plant is substantially the same, except that to secure greater reliability each pair of propelling engines has its own independent reduction gear, and the engines driving the ships' service generators are also built by M.A.N. This fact in itself is sufficient proof of the satisfaction given by the original installation. Table 1 presents the principal design data of these Diesel propelling plants in modern German warships.

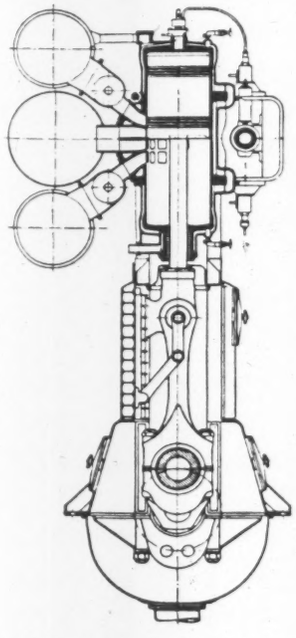

FIG. 5 M.A.N. DOUBLE-ACTING TWO-CYCLE DIESEL ENGINE USED IN THE GERMAN NAVY

Many interesting details in the design of the Diesel engines are used in the propelling plants of German warships. Pertinent numerical design data will be found in Table 2. However, only such other details will be briefly enumerated as may be of interest from an operator's point of view. All engines are directly reversible and all four engines, geared to one propeller shaft, can be maneuvered as a group by one lever or individually if necessary. Only upper cylinders are equipped with air starting valves. One fuel valve is used in the upper cylinder and two in the lower. Rotary valves control the exhaust ports. All pistons of double-acting engines have forged-steel heads and are oil cooled, while salt water is used for cylinder jackets and exhaust header. Engine framing is of welded-steel construction. The cylinder consists of a cast-iron central part carrying the scavenging and exhaust ports for both ends and two similar thimble-shaped steel end pieces with separate thin welded-steel jackets. Airless injection of fuel is used consistently. Fig. 5 is a typical cross section of this type of Diesel engine.

Fig. 6 shows a reduction gear with hydraulic clutches as installed in the motorship *St. Louis* which is similar to those in the German warships.

The two 26,000-ton German battleships *Scharnhorst*, launched Oct. 3, 1936, and *Gneisenau*, launched Dec. 8, 1936, are reported to have a Diesel cruising plant of unknown characteristics, while no information is yet available for the two 35,000-ton battleships, two 19,250-ton aircraft carriers, and three 10,000-ton heavy cruisers now building.

The twin-screw submarine tender *Saar*, launched April 5, 1934, of 2710 tons is propelled by Linke-Hoffman-Busch Diesels of 3700 total shp, while the tender for the high-speed torpedo-carrying boats *Tsingtau*, launched June 6, 1934, has a similar plant of 4100 shp.

DIESEL ENGINES IN MODERN WARSHIPS ELSEWHERE

Norwegian Mine Layer

An interesting example of Diesel engines for the propulsion of modern warships is offered by the propelling plant of the Norwegian mine layer *Olaf Tryggvason*,[2] a vessel of 1924 tons displacement with a maximum designed speed of 20 knots completed in the summer of 1934. The 6000-shp twin-screw propelling plant consists of two geared turbines developing a total of 4600 shp and two 700-shp series-wound direct-current motors each connected to a generator driven by an 850-bhp, 530-rpm eight-cylinder, four-cycle, Sulzer Diesel engine. Fourteen knots can be obtained on Diesel engines alone and fuel supply for a cruising radius of 3000 miles is provided. A maximum speed of 21.7 knots was attained on trials with both steam turbines and Diesel engines in operation. Astern turbines are provided and, therefore, maneuvering can be done with motors and turbines to permit either plant to operate independently. From the scant description of the plant available the following features of operation may be inferred: Exhaust gases of the Diesel

[2] "The Warship *Olaf Tryggvason*," *The British Motor Ship*, November, 1934, pp. 270–272.

TABLE 1 DESIGN DATA FOR DIESEL ENGINES IN MODERN GERMAN WARSHIPS

Name of vessel	*Königsberg*	*Karlsruhe*	*Köln*	*Leipzig*	*Nürnberg*	*Bremse*	*Deutschland*	*Admiral Scheer*	*Admiral Graf Spee*
Date of launching	3-26-27	8-20-27	5-23-28	10-18-29	12-8-34	1-24-31	5-19-31	4-1-32	6-30-34
Date of completion	1929	1929	1929	1931	Nov. 1935		1933	1934	1936
Total propelling power of Diesel engines, shp	1,600			12,000		26,000		54,000	
Maximum speed on Diesel engines, knots	10			18		27		26	
Number of engines	2			4		4		8	
Power of each engine, bhp	900			3,100		3,550		7,100	
Type of engine	Single-acting four-cycle M.A.N., 10 × 26/33[a]			Double-acting two-cycle M.A.N., 7 × 30/44[b]		Double-acting two-cycle M.A.N., 8 × 30/44[c]		Double-acting two-cycle M.A.N., 9 × 42/58[d]	
Number of auxiliary engines driving scavenging blowers and pumps				2		4		4	
Type				Double-acting, two-cycle M.A.N., 7 × 23/34		Double-acting, two-cycle M.A.N., 4 × 30/44		Double-acting, two-cycle M.A.N., 5 × 42/58	
Bore, in.				9.056		11.811		16.536	
Stroke, in.				13.386		17.323		22.835	
Speed, rpm				750		530		425	

[a] For details, see Table 2, line 1; [b] Table 2, line 2; [c] Table 2, line 3; [d] Table 2, line 4.

engines pass through exhaust-gas boilers, which also serve as mufflers, and generate sufficient steam not only to keep the blading of the steam turbines "cool" but also at higher speeds undoubtedly permit the latter to supply power to the screws, thus improving the fuel economy and cruising radius of the Diesel plant and doing away with the necessity of keeping the regular steam boilers under pressure which appears to be worth-while. This plant follows the lines of that on the British 6790-ton 27¾-knot mine layer *Adventure*, completed in 1926, which has in addition to its 40,000-shp geared steam-turbine plant a Diesel-electric plant of unknown capacity for cruising purposes.

Finnish Gunboats

Two twin-screw Finnish 4000-ton, 16-knot gunboats, *Vainamoinen*, completed late in 1932, and *Ilmarinen*, completed early in 1933, are also propelled by Diesel engines. Their plants are of 5000 shp, use Diesel-electric drive, and consist of two generators driven by high-speed W-type four-cycle Germania Diesel

TABLE 2 DESIGN DATA FOR MODERN NAVAL DIESEL ENGINES

Line no.	Type of engine	Cycle	Cyl-inders	Bhp Total	Bhp One cylinder	Bore, in.	Stroke, in.	Speed, rpm	Displacement, cu in.	Piston speed, fpm	Brake mep, lb per sq in.	Specific volume, cu. in. per bhp	Remarks
1	M.A.N. 10 × 26/33	4	10	900	90	10.236	12.992	900	10,660	1940	74.2	11.84	German Navy K-class cruisers
2	M.A.N. 7 × 30/44	2DA	7	3,100	443	11.811	17.323	600	27,580	1,732	74.2	8.8	*Leipzig*
3	M.A.N. 8 × 30/44	2DA	8	3,550	443	11.811	17.323	600	31,520	1,732	74.2	8.8	*Bremse*
4	M.A.N. 9 × 42/58	2DA	9	7,100	789	16.535	22.835	450	83,950	1,713	74.4	11.8	*Deutschland*
5	M.A.N. 3 × 64/96	2DA	3	6,000	2,000	25.197	37.795	263	107,500	1,655	84.0	17.9	French Navy experimental
6	Sulzer 3 × 68/94	2DA	3	6,400	2,133	26.772	37.009	267	118,600	1,646	80.0	18.54	French Navy experimental
7	Stearns	2◇	4	321	80.25	5¼	8½	1,300	1,470	1,840	66.6	4.58	U. S. Navy experimental
8	Winton	2V	12	950	79.17	8	10	720	6,040	1,200	86.6	6.36	U. S. Navy experimental
9	Sun Ship	2 O.P.	6	510	85.0	6½	9¾	650	3,890	1,050	80.0	7.62	U. S. Navy experimental
10	Continental	2 Rad.	10	480	48.0	6½	7½	1,100	2,489	1,375	69.4	5.18	U. S. Navy experimental
11	E. B. Co.	4 V	16	635	40.0	7	8¼	1,150	5,090	1,580	86.0	8.0	U. S. Navy experimental
13	H.O.R.-M.A.N.	2DA	8	1,300	162.4	9.056	13.386	700	13,570	1,561	54.25	10.4	H.O.R. experimental
14	F-M Co.	4	4	37.5	9.4	4¼	6	1,200	340.6	1,200	72.7	9.08	U. S. Navy standby generator
15	F-M Co.	4	8	120	15.0	5½	7½	1,200	1,425.6	1,500	55.5	11.88	U. S. Navy standby generator
16	F-M Co.	2 O.P.	6	300	50	5	6	1,200	1,414.1	1,200	70.1	4.71	U. S. Navy standby generator
17	Winton	4	3	37.5	12.5	5¼	7	1,200	454.7	1,400	54.4	12.11	U. S. Navy standby generator
18	Winton	4	6	150	25.0	6	8	1,200	1,357.0	1,600	73.1	9.05	U. S. Navy standby generator
19	McIntosh & Seymour	4	6	120	20.0	5½	9	1,200	1,283.0	1,800	61.8	10.60	U. S. Navy standby generator
20	McIntosh & Seymour	4	6	150	25.0	5¾	9	1,200	1,402.4	1,800	70.6	9.35	U. S. Navy standby generator
21	Cooper-Bessemer	4	8	150	18.75	5¾	7¾	1,200	1,610.1	1,550	61.5	10.73	U. S. Navy standby generator
22	Cooper-Bessemer	4	8	105	13.13	5½	7¾	1,200	1,473.1	1,550	47.1	14.06	U. S. Navy standby generator
23	Navy DA	4	4	25	6.25	3⅝	4½	1,428	185.8	1,060	74.7	7.46	U. S. Navy power boats
24	Navy DB	4	6	60	10.0	4	5½	1,700	414.8	1,560	67.4	6.91	U. S. Navy power boats
25	Navy DC	4	6	105	17.5	5¼	7	1,190	909.3	1,388	76.9	8.66	U. S. Navy power boats
26	Navy DD	4	6	105	17.5	4¼	5½	1,885	468.3	1,728	94.2	4.46	U. S. Navy power boats

Abbreviations are used in the column "Type of engine" to designate the various builders as follows: Continental, Continental Motors Corporation; Cooper-Bessemer, Cooper-Bessemer Corporation; E. B. Co., Electric Boat Company; F.-M. Co., Fairbanks, Morse & Co.; H.O.R.-M.A.N., Hoover-Owens, Rentschler Company; M.A.N., Maschinen Fabrik Augsburg-Nürnberg; McIntosh & Seymour, Diesel engine division of the American Locomotive Company; Stearns, Frank B. Stearns; Sulzer, Sulzer Bros.; Sun Ship, Sun Shipbuilding & Dry Dock Co.; and Winton, Winton Engine Corporation.

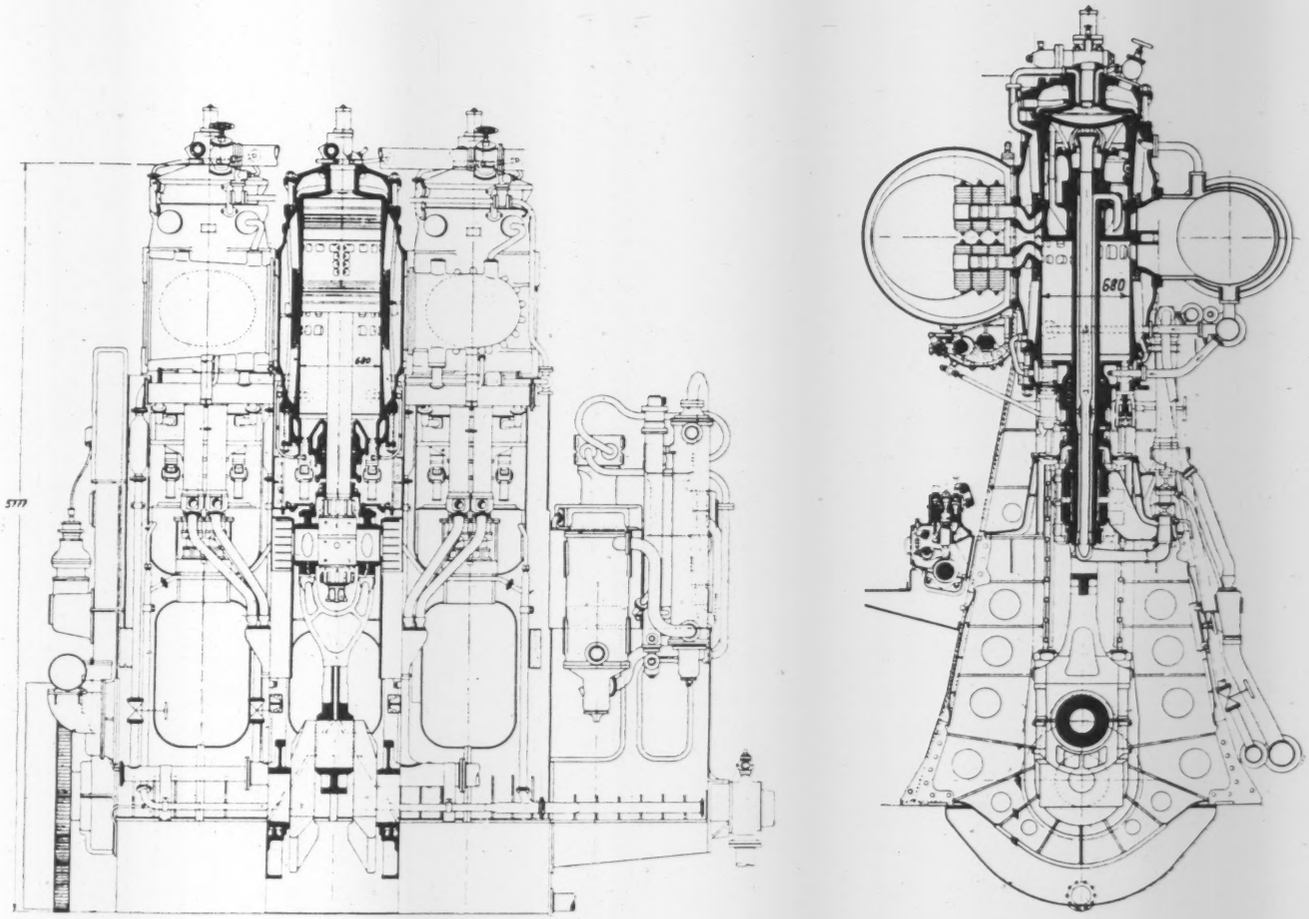

FIG. 7 EXPERIMENTAL SULZER THREE-CYLINDER DOUBLE-ACTING TWO-CYCLE 6000-BHP DIESEL ENGINE BUILT FOR THE FRENCH NAVY

engines, supercharged on the Büchi system and two motors, one on each shaft.

French Submarine Tender

The French twin-screw submarine tender *Jules Verne* of 5747 tons, launched Feb. 3, 1931, is propelled by two eight-cylinder two-cycle Sulzer Diesel engines developing a total of 7000 shp. These engines are coupled directly to the propeller shafts. They are directly reversible, of the air-injection type, and at the time of their shop tests in 1925 created a sensation by developing 6000 bhp at 280 rpm in eight cylinders of 650-mm bore and 680-mm stroke.

Japanese Submarine Tender and Mine Layers

The Japanese 10,000-ton submarine tender *Taigei*, launched Nov. 16, 1933, is propelled by four sets of Diesel engines totaling 13,000 shp and developing 20 knots. The mine layer *Itukusima*, launched May 22, 1929, is a triple-screw vessel of 1970 tons displacement propelled by three Diesel engines of 1000 shp each. Another mine layer, the *Nasami*, which was launched on March 26, 1934, is of 443 tons and is equipped with two sets of Diesel engines totaling 2300 shp and develops a speed of 19 knots.

Polish Mine Layer

The *Gryf* was built in France and was launched Nov. 29, 1936. It is of 2227 tons and its two sets of Sulzer Diesel engines totaling 6000 shp give it a speed of 20 knots.

Swedish Icebreaker

Sweden boasts the honor of having the first large icebreaker equipped with Diesel engines as a naval auxiliary. The *Ymer*, launched in 1933, is of 3465 tons displacement and develops 18 knots on its Atlas Diesel engines totaling 9000 shp.

6000-Bhp Experimental Diesel Engines

Agitation caused by the Diesel-engine propelling plants for the German pocket battleships resulted in the French Navy ordering from two different sources, Sulzer Bros. and M.A.N., a three-cylinder 6000-bhp experimental unit with the reported purpose of having four 12-cylinder 25,000-bhp units of this type for the direct drive of a large French warship. Eventually in 1931 both of these experimental units were completed and tested and some test data were published.[3] The French Navy Department is believed to have obtained a license to build the M.A.N. engine of this size but no further progress of the project has so far been reported. This M.A.N. type 2000-hp cylinder size follows the essentials of the design that was used in the *Deutschland*.

The Sulzer Brothers design of a similar two-cycle double-acting type of engine also of approximately 2000 hp per cylinder is illustrated in Fig. 7. Following the completion of tests on the three-cylinder experimental unit no official news on the progress made with this design is available.

[3] "Recent Developments in Diesel-Engine Construction," *The British Motor Ship*, January, 1933, p. 375.

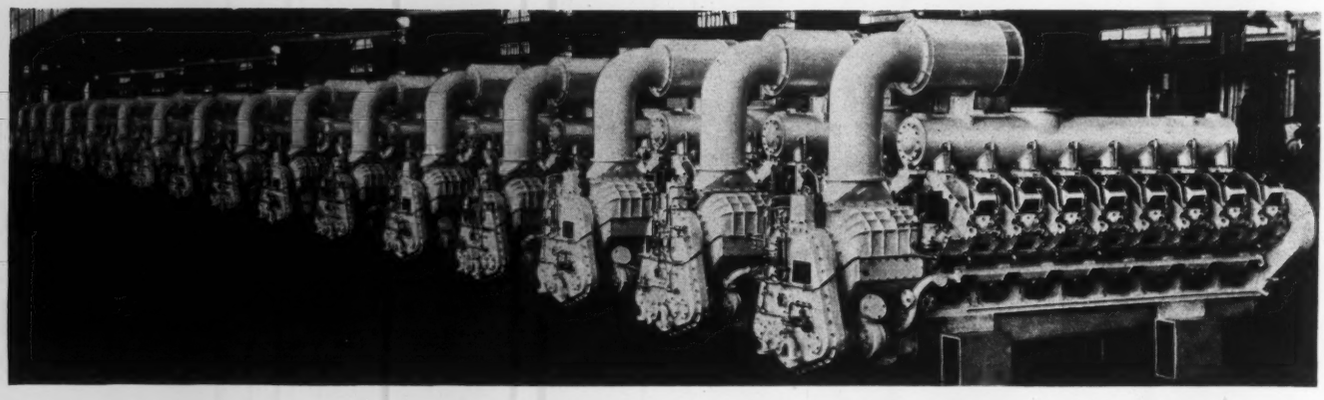

FIG. 8 GROUP OF 16 WINTON TWO-CYCLE V-TYPE DIESEL ENGINES BUILT FOR THE U. S. NAVY

Necessity is said to be the mother of invention, and the father of courage, I would like to add: Forced by the necessity of building new submarine tonnage of considerably increased speed, which required 2 hp to be developed on the weight allowed for 1 prior to that, Admiral S. M. Robinson, chief of the Bureau of Engineering, had the foresight and courage to take advantage of the then prevailing "depression" with resultant abundance of available engineering talent and great anxiety of all engine builders to keep their engineering organization intact and occupied.

HIGH-SPEED DIESEL-ENGINE PROGRAM OF U. S. NAVY

In the beginning of March, 1932, a circular letter was therefore addressed to all Diesel-engine and several gasoline-engine builders inviting them to submit proposals for a unit consisting of a high-speed Diesel engine and a generator. The weight of such a unit was restricted to $27\frac{1}{2}$ lb per bhp of the engine but no limitations as to type or cycle, number and disposition of cylinders, speed, and mean effective pressures were imposed.

By December, 1932, five companies had signed a contract with the Navy to deliver either a complete unit of desired size or a part of one capable of expansion into sizes desired by the Bureau. All of these units have passed their acceptance tests but of course with varying degrees of success as would be expected.

Frank B. Stearns of Cleveland, who prospered by developing the Knight sleeve-valve engine for the automobiles he had been building up to 1925, was interested in the development of a high-speed Diesel engine as a hobby and was the first to respond with a proposal to build a so-called "diamond type" engine of which he had a small-bore unit then running.[4] Such unit is composed by superimposing two V-type engines so that the upper cylinders have a common combustion space with the lower. The unit contracted for had two diamonds or eight pistons of $5\frac{1}{4} \times 8\frac{1}{2}$ in. with a maximum rating of 321 bhp at 1300 rpm. Details of this engine are given in Table 2, line 7.

After many difficulties the engine was accepted by the Bureau and was set up at the Engineering Experiment Station, Annapolis, Md., for further testing. However, a weakness in design developed and the engine wrecked itself, thereby concluding the development of this type. Although success had been denied Mr. Stearns, probably because he tackled too many problems without assembling a sufficiently qualified personnel to solve them, nevertheless he deserves credit for having served as a "catalyst," initiating events that led to success by others.

[4] "Automobile Pioneer Develops New Diesel Engine," *Oil Engine Power*, May, 1928, pp. 314–317; also: "The Stearns Diamond Diesel Engine," by Julius Kuttner, *Diesel Power*, February, 1932, pp. 65–66; also. "Navy Buys Novel Diesel—Stearns Engine Completes Tests," *Motorship*, April, 1935, p. 151.

The Winton Engine Corporation undertook to build a 12-cylinder V-type two-cycle engine developing 950 bhp at 720 rpm and employing exhaust valves in the head to obtain uniflow scavenging. This unit was based upon an 8×10 in. cylinder the design of which was by that time already far advanced. Test results of a single-cylinder experimental unit were sufficiently encouraging to permit the company to accept an order for two 8-cylinder in-line engines for the Chicago Century of Progress Exhibition which was to open in May, 1933. This engine, the data on which are given in line 8 of Table 2, was pioneering the use of a welded-steel housing.[5] It was duly completed and successfully passed the prescribed acceptance tests as well as additional tests at the experiment station at Annapolis, Md. A similar engine of an improved design was installed at the Submarine Base, New London, Conn., for instruction purposes.

The unprecedented success of this type of engine in the railroad field is common knowledge today, see Fig. 8, culminating as it did in the erection by the General Motors Corporation of a brand new manufacturing plant at La Grange near Chicago for the construction of the streamlined locomotives including the Diesel engines driving them. May not the U. S. Navy claim some credit for this success?

Sun Shipbuilding & Dry Dock Co. contracted to construct a six-cylinder, two-cycle unit of the opposed-piston, two-crankshaft type, similar to the one used by Junkers in Germany for airplane propelling plants. A $6\frac{1}{2} \times 9\frac{3}{4}$ in. cylinder size which was successfully built in a heavier construction with side rods was chosen (Table 2, line 9). The engine passed modified acceptance tests without any stop whatever and showed the most remarkable fuel consumption of 0.354 lb per bhp-hr. It is now undergoing further service tests. Outstanding features of this engine are its aluminum frame, which caused much delay in its completion since five partially machined castings had to be rejected before one could be used for assembling, and its twin geared generators designed for a maximum speed of 2900 rpm.

The Continental Motors Corporation was commissioned to combine its experience in building radial airplane engines with the design of the so-called "Argyle" sleeve valve and develop a radial two-cycle Diesel engine with uniflow scavenging through ports controlled by this valve. A ten-cylinder $6\frac{1}{2} \times 7\frac{1}{2}$ in. engine was designed to be mounted directly upon the bell-shaped housing of the generator. The unit passed acceptance tests at reduced rating and was installed for further testing at the New London Submarine Base. However, even at

[5] "Welded Steel Diesel Structures," by Everett Chapman, *Motorship*, September, 1933, pp. 404–409 and 412.

this reduced rating (Table 2, line 10) the company has every reason to be satisfied with its performance and is offering it commercially for locomotive purposes.

The Electric Boat Company preferred to build a four-cycle engine, equipped for supercharging, to satisfy the Bureau's requirements. A 16-cylinder, V-type, $7 \times 8^1/_4$ in. engine to develop 635 bhp at 1150 rpm (Table 2, line 11) geared to an 1800-rpm generator that was located directly below it, was contracted for. Outstanding features of this unit in addition to the speed and arrangement of the generator are

1 Aluminum engine frame, which delayed this engine also and for the same reason, five partially machined castings had to be rejected before one could be used for assembly.

2 So-called Lanova cylinder head, or rather combustion space to permit the high brake mep.

3 Floating bushing over the crankpin to permit higher crankpin pressures and therefore shorter distance between centers of cylinders and lighter weight.

4 Geared supercharging blower to increase the mep rating.

Many annoying minor troubles developed with this unit in addition to an exceedingly low priority which was habitually assigned to work on this unit by the management because of press of other more remunerative business. However, eventually all difficulties were overcome and the unit passed its official tests successfully and is now being held in readiness for further service tests.

Fairbanks, Morse & Co., although it originally declined to participate in the Bureau's program of development, shortly thereafter completed a new type of engine of the opposed-piston two-crankshaft type (line 16 of Table 2). This engine successfully completed the prescribed type-approval tests.

The Hooven-Owens, Rentschler Company, subsidiary of the General Machinery Corporation, also failed to take advantage of the encouragement given by the Bureau's development program, but later built on its own account a 1300-bhp engine in accordance with the Bureau's requirements. This engine is of the M.A.N. double-acting two-cycle type, similar to the engines used in the German Navy. It successfully passed the type-approval tests developing 1300 bhp at 700 rpm in eight double-acting cylinders of 9.056 in. bore and 13.386 in. stroke (line 13 of Table 2). This engine is the only representative of the double-acting type and is also employing a welded-steel frame in one piece.

DIESEL ENGINES FOR DRIVING STANDBY GENERATORS

A Diesel-driven generator is the logical solution of the problem to supply electrical energy in emergencies when the normal source of it fails to be available for some reason. A large number of high-speed units of several different sizes and makes have now been installed (see Table 2, lines 14 to 22 and Figs. 9, 10, and 11). Both air and electrically started units have been developed.

These units are all elastically mounted (see Fig. 9) to eliminate the effect of engine vibration on the ship's hull. Several different types of spring vibration damper have been used with success so that now elastic mounting is being specified even for the largest ship's service generator units.

DIESEL ENGINES FOR POWER BOATS

The author has dealt in detail with the development of this type of engine in a previous paper[6] and it is intended here only to summarize briefly the results. Forced by the necessity of eliminating the dangers of gasoline as soon as possible the Bureau purchased samples of all engines available in 1932. These were tested at the Annapolis Engineering Experiment Station on the dynamometer and in a specially constructed cold chamber to assure reliable starting under most adverse service conditions. Eventually the Bureau contracted with the Buda Company to supply a substantial number of engines of three different sizes and obtained a license for their reproduction at the Norfolk Navy Yard. (See Table 2, lines 23–25.)

Weight and space requirements of these engines exceed but little those of the gasoline engines that they replaced and the fourth size of engine (Fig. 12 and Table 2, line 26) that was developed recently is even lighter than a gasoline engine. All of them can be started with normal equipment at temperatures as low as 20 F and with additional equipment even at 20 F below zero. Legal restrictions forced the Bureau to develop the domestic manufacture of standard fuel-injection equipment and one of the first commercial fuel pumps produced by the Ex-Cell-O Aircraft & Tool Corporation successfully passed rigorous

[6] "Diesel Engines for Power Boats of U. S. Navy," by E. C. Magdeburger, *Journal of the American Society of Naval Engineers*, vol. 48, 1936, pp. 68–89.

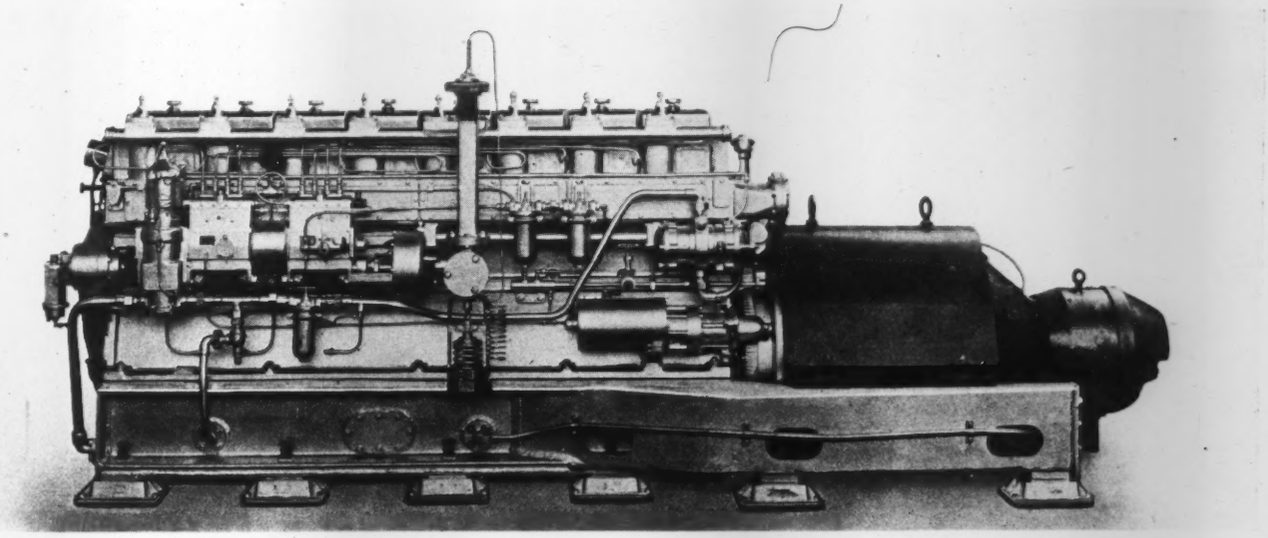

FIG. 9 COOPER-BESSEMER STANDBY DIESEL GENERATOR BUILT FOR THE U. S. NAVY

testing at Annapolis and was adopted. The original test pump is still in service together with several hundred others which have been supplied since then. Lately two other commercial pump manufacturers established domestic production of fuel-injection equipment and these will be tested as soon as practicable.

As the result of the Bureau's insistence on weight reduction the Buda Company acquired the Lanova license,[7] which permits a higher output with minor modifications of combustion space, and this resulted in the purchase of several previously mentioned DD engines, which will also be built at the Norfolk Navy Yard.

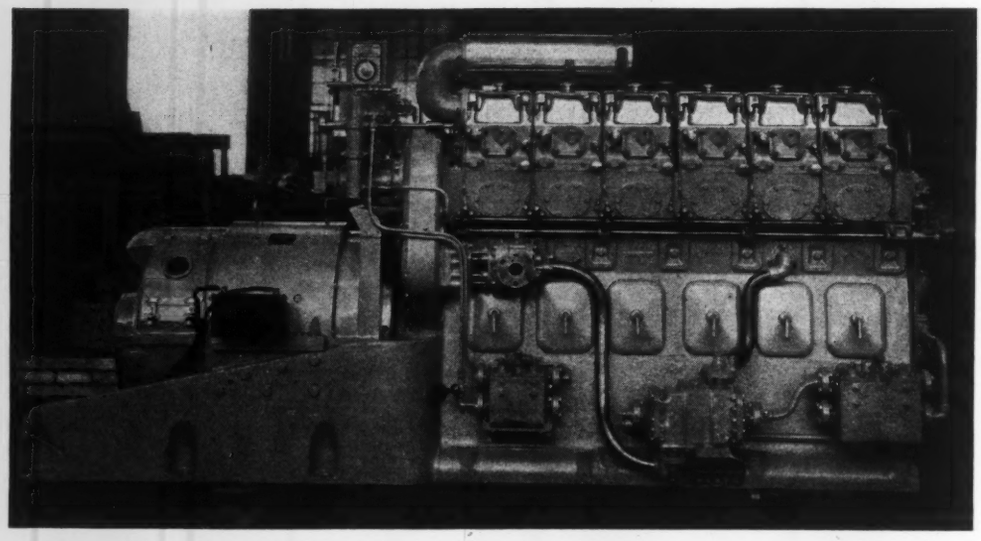

FIG. 11 WINTON STANDBY DIESEL GENERATOR BUILT FOR THE U. S. NAVY

DIESEL ENGINES FOR AUXILIARY SHIPS

To provide employment during the peak of the depression the Bureau prepared plans and specifications to re-engine several wartime steam-driven tankers[8] but the program did not materialize. Need, however, for efficient auxiliary ships of the fleet has been growing as time goes on and it is now hoped that before this paper is delivered Congress will provide the authority and the means to proceed with the Navy's auxiliary program. In anticipation of the forthcoming need for providing a modern power plant for several types of ship of this program the Navy has secured funds and entered into contract with three qualified Diesel-engine builders to construct and test experimental three-cylinder engines of about 700 hp per cylinder. As the result of this action by the Navy the three world's outstanding designs of large-size double-acting two-cycle Diesel engines have been obtained, Burmeister & Wain by Nordberg Mfg. Co., M.A.N. by General Machinery Corporation, and Sulzer by the American Locomotive Company, and will thus become available for future needs of the Navy, the U. S. merchant marine, and other applications.

[7] "Characteristics of Lanova Combustion System," *Diesel Power*, August, 1936, pp. 517–521.

[8] "Naval Tankers to Be Converted to Geared Diesel Drive," *Motorship*, October, 1933, p. 433; also: "Marine Diesel Engineering in the Navy Department," *Motorship*, December, 1933, pp. 511–513 and 534.

FUEL AND TORSIONAL VIBRATION RESEARCH

With the foregoing commitments to the use of Diesel engines it is only natural that the Navy, coincident with the development of the programs mentioned, proceeded with the study of the type of fuels required for the proper operation of these new types of Diesel engine. Experimental equipment and qualified personnel have been assembled at the Engineering Experiment Station, Annapolis, and funds secured for a thorough and systematic study of fundamental properties of Diesel-engine fuels. Another paper before this conference is scheduled to deal with the results obtained by this activity of the Navy.

All engineers in any way connected with the development of Diesel engines are well aware of the effect of this malicious malady, torsional vibration, in retarding the growth of the industry. Without going into further details of the reasons why in the layman's mind the Diesel engine became the birthplace of torsional vibration suffice it to say that the Diesel engines suffered the most from it because the reciprocating mechanism of its predecessor, the steam engine, was not developed for the higher speeds and resultant multiplicity of torque impulses.

Torsional vibration thus becoming an obstacle in the way of progress with Diesel engines, the Navy proceeded to study it courageously and painstakingly. Many outstanding papers by naval personnel and by academic consultants engaged on naval problems have been presented in the

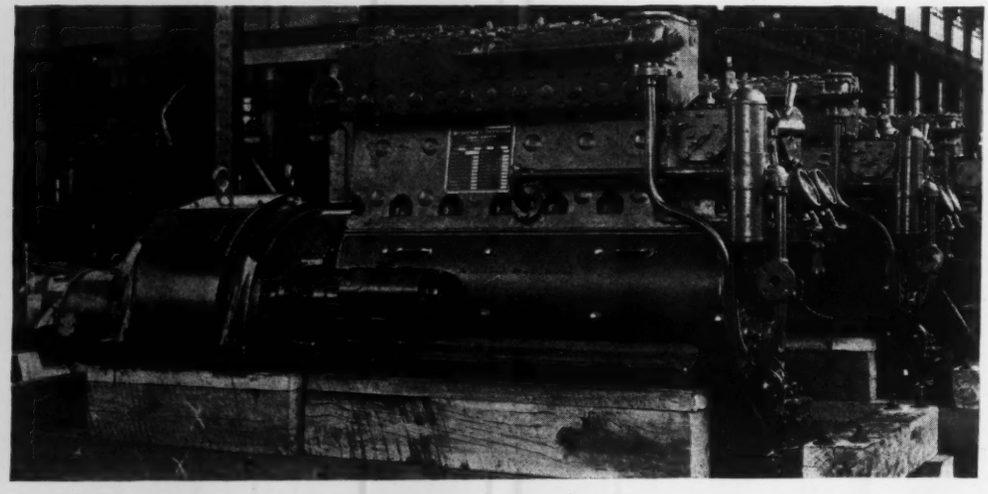

FIG. 10 MCINTOSH & SEYMOUR STANDBY DIESEL GENERATOR BUILT FOR THE U. S. NAVY

last 12 years[9] with the result that the high-speed Diesel engine of today need not suffer from the consequences of torsional vibration if its designers are willing to consult specialists or can spare time to study the subject.

INSPECTION OF NAVAL MATERIAL

If any credit is to be claimed at all for the part that the U. S. Navy played in developing modern high-speed Diesel engines, the Inspection Service of the Navy must not be overlooked. The uncompromising attitude of this fine group of men, consisting of a permanent civilian force headed by commissioned officers of the Navy is frequently but little appreciated by the engine builder's management which places profits before future. Designers of new types of engine are usually unanimous in their appreciation of the Navy inspection which takes no cognizance of unwritten precedents or established shop practices if these are at variance with the requirements of the approved drawing, which represents the designer's concept modified, if need be, by the operating experience of the Bureau. Being thus independent of the shop and not subject to pressure by the management the inspection comes closest to the ideal than any industrially established system.

[9] "Torsional Vibration in the Diesel Engine," by F. M. Lewis, Transactions of the Society of Naval Architects and Marine Engineers, vol. 33, 1925, pp. 109–145; also: "The Range and Severity of Torsional Vibration in Diesel Engines," by F. P. Porter, Trans. A.S.M.E., vol. 50, 1927, paper APM-50-8; also: "The Elimination of Torsional Vibration," by G. J. Dashefsky, Pennsylvania State College School of Engineering Technical Bulletin No. 12, 1930, pp. 193–267.

This review of basic facts was intended to present only a broad picture of the U. S. Navy sponsoring development of many types of Diesel engine, without going into details that would make the paper unwieldy and unread. To those who have the time to follow any particular phase of these developments many excursions into the details have been suggested by the footnote references.

SUMMARY AND CONCLUSIONS

Summarizing briefly, the following are the reasons why the U. S. Navy will keep on contributing to developing the best types of propelling machinery.

Necessity drives the U. S. Navy to outguess the world in the type of propelling machinery it uses. Being thus always dependent on new developments for its supremacy the personnel of the Navy develops the proper attitude for constructive progress. This attitude is reflected in Navy specifications wherein no limitations are prescribed if proof of performance is available. "Hold nothing holy" is the proper motto for research, but in the interest of economy, of time more than of money, do not neglect the facts established by others long before.

In conclusion the author desires to pay tribute to that large body of highly trained men afloat, both officers and enlisted men, who by their faith, enthusiasm, and intelligent nursing of the new types of Diesel engine make the largest contribution of the U. S. Navy. They establish public confidence in these new engines and thereby lay the foundation stones for their acceptance; it is used in the U. S. Navy.

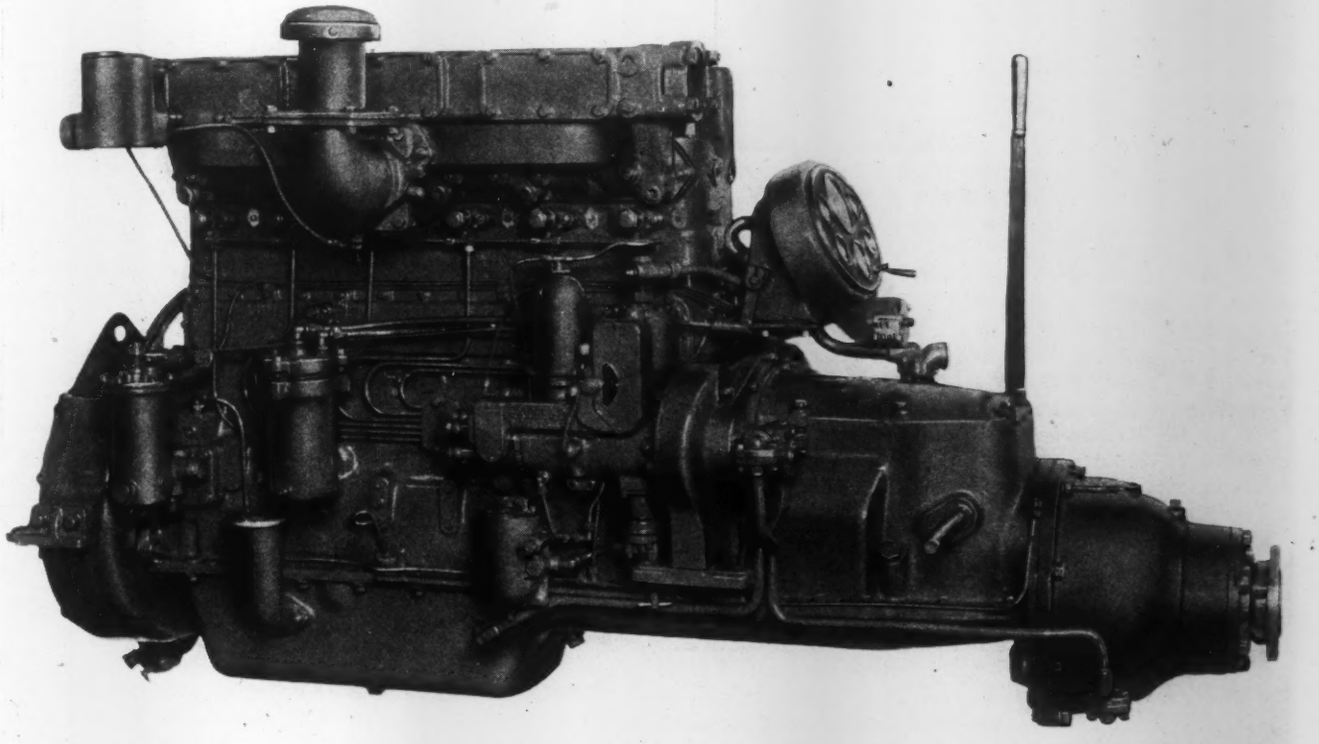

FIG. 12 NAVY TYPE DD (BUDA-LANOVA) DIESEL ENGINE THAT WAS DEVELOPED BY THE BUREAU OF ENGINEERING FOR USE IN POWER BOATS

Developments and Problems of AIRCRAFT ENGINES

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SURVEYING engine developments reveals no outstanding feature that might be called revolutionary, but rather the achievements made have been the result of numerous detail advances in design and materials. Changes that have improved engine characteristics have, in most cases, been due to application of designs and ideas which heretofore could not be put into practice because of limitations in materials and shop technique. All advances that have been made can probably be classed under the general headings of fuel and design. Fuel and engine developments are so closely allied that improvements in economy, power, or specific weight can usually be attributed to better fuels as well as improved design.

HIGH-OCTANE FUEL

Development of higher-octane fuels has probably been one of the most important contributions to the aircraft industry by increasing engine power, without increasing the displacement, and with a decrease in specific weight. Prior to the development of 100-octane fuel, full-throttle operation at sea-level conditions with highly supercharged engines was impossible without entering the detonation zone due to high compression pressures and the type of fuel. With this new fuel, increases in power and also the operation of highly supercharged engines at open throttle at sea level without danger of detonation was made possible, providing, of course, that sufficient cooling was available to prevent excessive temperatures of the head at this high power output per cylinder. Operations with this new fuel have shown that an increase of over 30 per cent in power could be safely gained over that formerly obtained with 87-octane fuel in the same engine, with only a slight increase in weight due to the greater stresses imposed on the engine with the power increase.

Possible future importance of the higher-octane fuel to the operator can be better realized from the tests conducted by Raymond W. Young of the Wright Aeronautical Corporation, in which the results indicated that fuel consumptions as low as 0.34 lb per hp-hr could be obtained in the cruising range without excessive cylinder temperatures by using 100-octane fuel. This represents a saving of approximately 20 per cent over the best economy obtainable with Army 92-octane fuel.

A new method of obtaining high-octane fuel has been proposed by L. H. Kimball of the Fuel Development Company and is at present in use by some air-line operators. A blend of aniline and alcohol, known as "Anilol," is used as an antiknock compound and is injected into the carburetor in controlled quantity to give the desired octane rating to the fuel used. The injection valve can be linked with the throttle to give an automatic increase in octane rating of the fuel with increased power. It cannot be added to the gasoline in the tank because it is not miscible with gasoline. At present Anilol is used with gasoline that has a 2.5 cc lead content, but it can be used in unleaded fuels with equally good results. This latter point is of great interest since elimination of leaded fuels would solve many maintenance problems that are traceable to the lead compounds.

Condensed from an address before the Philadelphia Section, Philadelphia, Pa., Oct. 27, 1936, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

FUEL CONSUMPTION AND POWER CONTROL

Although the engine's physical make-up has permitted extremely low fuel consumption, maintaining it under extremely variable atmospheric conditions of operation became problematical. In a survey covering numerous trips by various pilots over the same route using manual mixture controls, results indicated a variation in fuel consumption between pilots of as high as 30 per cent. Until the present, mixture control was maintained manually by the pilot. Fuel-air ratio would be gradually increased until the tachometer showed a slight drop in revolutions per minute and then would be richened slightly to regain the lost speed. This would indicate maximum power at minimum fuel consumption. Some pilots were too anxious to operate at minimum fuel consumption and tended to enter a field of excessive leanness, others with an eye toward low temperatures and high power gravitated toward extremely rich mixtures, either case resulting in higher operating costs in maintenance or fuel. Even unintentionally, the pilot would enter extreme mixture conditions because he was occupied with the other 100 odd instruments and controls that require his attention in flight. Secondly, these difficulties due to fuel consumption were further increased with the introduction of the constant-speed propeller. Constant-speed operation no longer gave the pilot a tachometer mixture check, since no matter what the power output or mixture was, the speed remained the same within a limited range. As the engine power dropped the propeller pitch automatically decreased to maintain constant operating speed.

Tied up closely with the mixture-control problem was that of restricting the power output at any altitude to the maximum allowable. Engines were now supercharged to develop rated sea-level power at altitudes of 7000 feet or more. Unless the throttle was carefully set the possibility of exceeding the rated horsepower at altitudes below the rated one was always inevitable. This power output has been usually checked by carefully controlling the throttle to maintain a manifold pressure that would not permit exceeding the rated power, but here again, with the great responsibilities and numerous controls requiring the pilot's attention, results obtained with manual operation were never satisfactory.

In an effort to overcome this condition, various types of automatic power and mixture control were developed. That discussed by Beardsley,[1] before the Society of Automotive Engineers, operates on the principle of maintaining a constant density and temperature below the carburetor by automatically adjusting of the volume of preheated air taken into the carburetor scoop and an automatic restricting flap valve at the

[1] "An Automatic Power and Mixture Control for Aircraft Engines," by G. E. Beardsley, Jr., S.A.E. Transactions, vol. 30, 1935, pp. 301-306

scoop that limits the flow of the air into the carburetor and thus maintains the density at the equivalent of that at the altitude for which the engine is rated.

In addition to an automatic device of this type, maintaining a visible check on the mixture is always desirable. The majority of transport ships therefore use a Cambridge or Breeze exhaust analyzer as standard equipment to which the pilot can refer from time to time as a check on the operation of the automatic control.

Reports from air-transport maintenance departments indicate that the time between overhauls which has risen from 300 to 600 hours can be traced to a large extent to the use of automatic controls.

PREVENTING ICE FORMATION IN THE CARBURETOR

In line with power output and mixture control, something might well be mentioned about developments in carburetor deicing, long a difficult problem to air-transport operators as has been deicing of propellers and wings. Many unexplained accidents in the past undoubtedly resulted from icing conditions in the carburetor and only recently has the importance of this type of icing been realized. Icing in general has always been a problem to the aircraft operator, but formations in the carburetor are not visible and therefore power losses or failure had rarely been attributed to icing until the mechanics of carburetor icing were fully realized. This condition of the carburetor, unlike icing of the wings or propellers, was not confined to winter operation but could and did occur even in atmospheric temperatures as high as 60 F, provided the proper conditions of humidity and temperature drop in the venturi were encountered.

Perhaps an explanation of this phenomenon would not be out of order. A certain percentage of fuel leaving the jet vaporizes as it travels through the venturi and throttle section. This vaporization requires heat which is drawn from the surrounding air, causing a temperature drop as much as 28 or 30 F. If, at the same time, the humidity at atmospheric temperature is such that cooling to freezing increases the humidity beyond 100 per cent, precipitation of excess moisture will occur. Condensed vapor will mix with the gasoline in minute quantities, because the water tolerance of gasoline is low, and the remainder of the water will remain unmixed. At low temperature water adhering to the venturi and butterfly will freeze, and as the process is continuous layer after layer is built up so that the opening at the venturi and the butterfly is greatly reduced, causing a serious loss in engine power. Ice formation is rapid, and in some cases only a minute or two elapses before engine power is seriously affected. The obvious solution of this condition is preheating intake air to temperatures that will maintain temperature in the venturi above freezing. High temperature should be maintained at all times since much more heat is required to remove the ice than to prevent it. Use of a preheating device has introduced difficulties due to corrosion of the preheating tubes by exhaust gases, although recently various transport companies have been using rings of Iconel metal which they claim have been satisfactory. Other disadvantages that are likely to be encountered are loss of volumetric efficiency and possibility of entering the detonating zone as a result of high intake temperatures.

These particular disadvantages can be successfully eliminated by injecting alcohol at the venturi or using alcohol-blended fuels, both of which are extremely effective in ice prevention or elimination. Tests made by the author at the Daniel Guggenheim Laboratory on Callis alcohol-blended fuels successfully demonstrated that a period of less than a minute was required to eliminate entirely ice formations which had lowered the engine speed from 1800 to 1000 rpm. Air would have to be preheated to between 60 and 77 F above that at which the formation occurred to obtain comparable results with heat. Automatic alcohol-injection systems, where the alcohol is injected into the carburetor at the venturi from an alcohol tank, have given similar results.

Besides alcohol and gasoline, Callis alcohol-blended fuel contains a stabilizing agent whose use increases the water tolerance of the mixture or the quantity of water that the fuel can absorb without separation occurring. Another interesting point is that the stabilizers used by Dr. Callis will make mixtures of aniline and alcohol miscible in gasoline, which should open a new field for Anilol as an antiknock compound.

A recent addition to the deicing field is the Chandler-Groves nonicing carburetor, a somewhat radical departure from conventional types which is claimed to eliminate completely any icing difficulty without recourse to blended fuels or heat. It has other unusual constructions which deal with fuel flow and action under violent maneuvers, but ice elimination is by far the most interesting feature. The carburetor is designed with two modified cylindrical sectors that are located on either side of the main jet and, because of their shape, provide the venturi effect required at the jet and the throttle control desired. Basically, the fixed venturi and throttle valve in the standard carburetor are replaced by a flexible venturi in the Chandler-Groves which does the work of both devices. Under this arrangement, fuel leaves the jet and encounters no valves or restrictions within the carburetor, as it does in the standard type, and little heat can be absorbed by the vaporizing fuel from the carburetor proper, thereby reducing or eliminating any icing possibilities. Should conditions require, the throttle-venturi sectors can be readily heated, but in accordance with published data this is not necessary. The carburetor has, to date, undergone some 2000 hours of testing on high-powered engines with satisfactory results.

DAMPING TORSIONAL VIBRATION

Much has often been said concerning the serious torsional vibration existing in the radial engine, and not until recently has the problem been given enough attention and thought to provide a solution. Engineers of the Wright Aeronautical Corporation developed a dynamic damper that has reduced periodic torsional vibration to the minimum. This development represents, without question, one of the most valuable contributions to aircraft-engine design in many years and has been obtained without adding any weight to the engine, which, in itself, makes this advance all the more interesting. Also, the system does not depend upon conversion of energy as in friction dampers.

In principle, the dynamic damper is a pendulum mounting for one crankshaft counterweight instead of the conventional rigid mounting. This pendulum action is accomplished by mounting a counterweight having the mass necessary to balance the engine in such a manner that it can vibrate through a small angle when disturbed. The counterweight is supported upon two rollers which are loose in holes both in the crank cheek and counterweight as illustrated in the drawing at the left in Fig. 1. This makes the assembly equivalent to suspending the counterweight from the cheek by two links as illustrated in the other drawing. With either type of suspension, all points of the counterweight move in a circular path, and the counterweight as a whole has a parallel motion, behaving as a simple pendulum.

Stops are provided to limit the counterweight's motion during sudden accelerations. These stops are arranged to permit a motion which is considerably in excess of that required for complete damping at any speed. In normal operation therefore the

counterweights are never sufficiently disturbed to strike the stops. When the counterweight is displaced, the restoring force is centrifugal and therefore varies with the square of the revolutions per minute and the damping effect increases with the speed as desired. The damper's period is designed to be $4\frac{1}{2}$ times the crankshaft speed and is equal to that of the power impulses in the nine-cylinder radial engine, thus smoothing out the torsional oscillations that are ever-present in rigid-counterweight engines resulting from torque variations. Use of the dynamic damper has been estimated to have smoothed out the Wright engine to give an equivalent torsional oscillation of an 18-cylinder engine of equal total displacement.

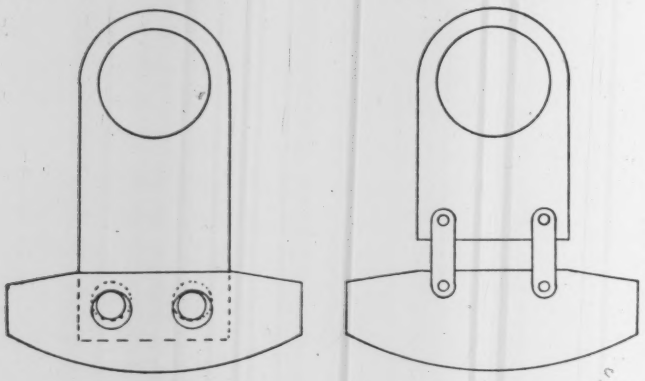

FIG. 1 ASSEMBLY (LEFT) AND EQUIVALENT LINKAGE (RIGHT) OF THE WRIGHT DYNAMIC DAMPER

A system of this type is independent of the crankshaft and propeller vibration characteristics and is dependent only on the torque characteristics of the engine. Therefore, it can be used without modification on either geared or direct-drive engines of the same type.

CHOICE OF MATERIALS AFFECTS ENGINE CONSTRUCTION

Effect of materials on engine construction, although not as spectacular as the mechanical and fuel developments, has been of utmost importance in securing weight reduction, increased power, and longer life of present-day engines. Last year's most outstanding trend has been increased application of magnesium-alloy forgings and castings in low-stress sections, such as cover plates, housings, and some crankcase assemblies. Not so many years ago magnesium alloys were regarded as so unstable and corrodible that they were not believed to be dependable for engine parts. Development of fluxes having sufficient viscosity to protect molten metal and which could be kept out of the final casting and improved foundry technique have done much to reduce these unfavorable characteristics. Stability against salt corrosion has been solved satisfactorily by dichromating the surface. Physical characteristics of magnesium are generally lower than in aluminum alloys, but these deficiencies are somewhat balanced by its low specific gravity which is approximately 65 per cent of the other. Ease of machining magnesium as compared with aluminum serves to reduce manufacturing cost even though the material's original cost may be higher. Through proper design and application of magnesium alloys savings of approximately 30 per cent over aluminum alloys, can be obtained. Use of magnesium alloys will probably increase with a better understanding of their qualities and recent improvements.

Stellite on the faces has increased valve life tremendously. It has been welded to the valve face, thereby producing a hard surface. Working against a seat of silicon-chrome-tungsten steel, both valves and seat are practically immune to pitting or corrosion. This is also effective in reducing the pounding-in of the valve to the minimum. Improvements in valve lubrication as well as materials have increased valve life from 800 to as high as 2000 hours in high-powered engines.

Nitriding steel cylinder barrels has contributed materially toward an increased period of usefulness. The process requires exposing the barrel in an oven filled with ammonia gas and maintaining a temperature of 950 F for 48 to 72 hours depending upon the depth of hardening required. The hardness obtained is approximately 1000 Brinell.

These outstanding improvements as well as numerous changes in composition, heat-treatment, and the like have contributed greatly both to decreased weight and to lessened maintenance problems.

PROBABLE DEVELOPMENTS IN THE FUTURE

Combining these individual improvements in a single unit has made large increases in power output and dependability possible in the modern engines. Improvements already made have indicated in which direction future gains in characteristics might be expected and, as always, have also shown probable difficulties to be encountered.

Increased supercharging which is inevitable with future advances in power will make the problem of manifold temperatures important. Some effective method of cooling the air after it has been compressed through the supercharger will have to be devised to avoid detonation from high intake temperatures and also to increase the volumetric efficiency of the unit. Perhaps finning the supercharger case and also locating the unit in the nose section to obtain maximum cooling may be the answer. Whatever the solution, the problem will prove to be important. Demand for high-altitude operation will require incorporation of an altitude booster supercharger, which will probably bring about a return of the exhaust-turbine unit. This type is satisfactory and efficient for high-altitude operation.

High-speed geared engines may be another method of increasing power output without any great addition in weight. This is theoretically an ideal solution, since power does vary with speed. Practical problems of gear losses, vibration, materials, and piston velocity versus rate of combustion must be solved before any great increase in speed can be expected in high-powered engines. Although even at present, various individual designers and engine companies behind "No Admittance" doors are experimenting on high-powered engines at speeds ranging as high as 5000 rpm, results of this work will not be evident until the designs and test data are released.

Use of 100-octane fuel throughout the operating range will be prevalent for reasons already covered. Further improvements in fuels, with perhaps the development of higher-octane fuels for application with higher compression or manifold pressures than is at present possible, undoubtedly will also be made.

Engine noise will become more and more important in the future. At present, passenger comfort has been secured by soundproofing the cabins. Whether or not increases in power and in the number of ships in the air will make the noise problem one in which the comfort of the public may be important is a subject for speculation. Some work is being carried out on aircraft-engine mufflers. The effectiveness of no one unit has been presented as yet, but perhaps next year may see an efficiently muffled aircraft engine.

On the whole, much apparently will have to be done before single power units of 1500 hp or more can be developed which will give the dependability and life of the present production

(*Continued on page 687*)

Economic Aspects of AGRICULTURAL-PRODUCT DRYING

By CHARLES W. THOMAS

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AS TIME advances each period brings changed living conditions. Most important are the changes that affect the health and vitality of the nation. Food supplies and their distribution are the most important items which must be given careful consideration.

The last few years have been full of lessons to the food producers and the food industry. Even though we are fortunately not compelled, like other countries, to exercise the greatest economy and efficiency in food production and preservation to supply our needs, the wisdom of practicing more discrimination in using the products of the soil appears well justified in the light of past events and anticipation of the future.

Not that we have not had men with foresight, who have seen the need for change and adjustment due to altered conditions. The burden of providing for the future has always rested upon the shoulders of a few. The majority of people do not give the future any thought and let others do the worrying.

CHANGES AFFECTING THE FOOD SITUATION

What are the changes that will affect the food situation and how will they have to be met? We shall classify them as follows:

(1) Changes in census and changes in the average age of the population
(2) Changes in diet
(3) Changes in methods of living
(4) Changes in cultivable and grazing areas
(5) Wars and other events.

O. E. Baker, of the Department of Agriculture, in an address, at Iowa State College, Feb. 9, 1934, stated

> that although the total population may not change greatly for one-third to one-half a century, there will be great changes in the number of children and old people living in rural and urban territory. . . . that based on 3 acres of cropland harvested per person, according to the 1930 census, in 1940 the nation will need 25,000,000 more acres of harvested crops, and in 1950 on the same basis, 35,000,000 more acres.

An important factor affecting consumption of farm food products is diet. According to the same report, $2\frac{1}{2}$ acres of cropland and about 6 acres of pasture per person per year, are available in the United States, compared with $\frac{1}{2}$ acre of cropland and $\frac{1}{2}$ acre of pasture per person per year for Germany, $\frac{1}{2}$ acre of cropland and little pasture for China, and only $\frac{1}{4}$ acre of cropland for Japan.

Yields per acre are higher in Germany and Japan, but a difference in diet also helps to explain how these countries manage to get along with so little cropland. The change from cereals and dairy products to an increase in vegetables, eggs, and meats, increases the acreage required.

Dr. Stiebling and Miss Ward, Bureau of Home Economics, Department of Agriculture, Washington, D. C., made a study of diets and arrived at the following:

(1) Emergency restricted diet, consisting largely of cereals, requires 1.2 acres of cropland to feed the average person for one year. Deficiency diseases might develop within that time.
(2) Adequate minimum-cost diet, including more milk, meat, fruits, and vegetables, would require 1.8 acres per capita.
(3) Adequate moderate-cost diet includes 1 qt of milk per day and an increase of fruits, vegetables, and meats over the minimum-cost diet and would require 2.3 acres of cropland per person, practically what is now used in the United States.
(4) Liberal or ideal diet calls for less cereals, 100 lb per year, which is about half the national average at present. It includes 1 qt of milk and over 2 lb of fruit and vegetables per day; nearly $\frac{1}{2}$ lb of meat per day, and in addition 1 egg per day. This diet would require 3.1 acres per capita.

Increasing density of population in the cities and the trend to "no kitchen work," "no washing, peeling, or waste," "just add hot water and serve" are not without effect on the food situation. The effect is that outlined above, namely, the need for additional food-producing areas.

INCREASED PRODUCTION AND CROP PRESERVATION

Responsibility assumed by our government to preserve resources and provide an ample food supply is better understood today, and this increasing obligation assumed by the government in matters concerning public welfare is now approved of by the people. One of the prime concerns of the government is to correct past mistakes which have resulted in floods and dust storms. The program of reforestation and land reclamation will no doubt decrease areas that were available for cultivation of food products.

The World War proved the value of dried food products, even though the products provided at that time were poor in quality and do not compare with what can now be obtained. Without question future conflicts will make heavy demands upon dried food products, because of their advantages in transportation and preservation. Such events as the Klondike gold rush which produced a heavy demand for lightweight products to carry in packs are not likely to be repeated, but unexpected devastations of areas by nature's forces may create a food shortage.

The foregoing brings up these main problems for consideration: (1) Increased production per acre; and (2) preservation of crops when grown so that they may be carried from one year to offset a shortage in another.

Presented at the Agricultural Processing Meeting, New Brunswick, N. J., Feb. 26, 1937, held under the joint auspices of the Process Industries Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, the American Society of Agricultural Engineers, and the Farm Chemurgic Council.

Increased production per acre is the problem of the agriculturist. Growing several crops that mature at different periods, on the same ground at the same time, also several cuttings of fodder crops in place of one final cutting are problems for his consideration. To harvest these crops, however, is another matter, since natural methods will not satisfy the conditions created by intensified cultivation.

Attention has been directed in recent years to the possibilities in soil yields by several crop cycles per year. Even in sections favored by ideal climate, such a scheme would be dependent upon artificial drying for its execution.

METHODS OF PRESERVING FOOD PRODUCTS

The following methods may be considered for preservation of food products:

(1) Smoking, which is confined to meats and fish and preserves for short periods only.

(2) Pickling, limited to few products in bulk for short periods and in glass for longer periods.

(3) Refrigeration. Frosted foods retain form, color, and taste but are expensive in distribution and require special storage facilities at retail stores.

(4) Canning. Canned fruits and vegetables when opened must be used promptly and will not keep in extreme climates. Besides high costs for canning, the transportation charges are high due to increased weight of canned products. They are much higher than for dried products as shown by the following comparisons: 2000 lb of canned peaches ready for shipment weigh 2850 lb whereas if dried they will weigh only 250 lb, and 2000 lb of spinach when canned ready for shipment weighs 2400 lb compared with 166 lb for the dried product.

(5) Silage, which is suitable only for cattle food on a small scale and only for short periods.

(6) Drying. Recognition of the necessary part that drying plays in a planned system of national economics is growing. For low-cost preservation of large quantities of produce which are capable of storage for a long time in a marketable condition, drying has no equal.

DRYING PREVENTS GLUTTED MARKETS AND REDUCES SPOILAGE LOSSES

The object of drying is conservation of the starch and protein content of these products. Both are subject to destruction by fermentation which sets in if moisture is present. By drying, converting an otherwise waste product into one of high food value is often possible. Converting readily spoilable surpluses will relieve glutted markets and regulate price levels without losses. In city markets it would reduce losses from spoilage and dumping to maintain prices. At present, truckloads that could be saved by drying are daily carted away from the wholesale markets.

For short-cycle field crops, artificial drying is the only answer because by natural drying much of the value would be lost. In England and other European countries, this scheme has received more attention than is healthy for a new development, with the consequent danger of bringing it into discredit due to indiscriminate application. However, some lessons may be learned from the experiences of these countries.

Drying of foods requires practical experience. Life and vitality must not be destroyed by improper drying. If drying is properly carried out, the objection heretofore raised against dried vegetables and fruits especially, namely, that they require too long to soak before cooking and that they do not reach the consumer in proper condition, would be overcome. Also no food poisoning will occur since no case of it has ever been traced to properly dried food.

Artificial drying is of inestimable value in connection with the carrying over of surpluses and equalizing differences in crops from one period to another. The government should find in artificial drying a good ally in the realization of its new granary program as well as in carrying out its soil-conservation and price-regulation policy.

Harold Harvey, Nesmith

Technical Aspects of AGRICULTURAL-PRODUCT DRYING

By ARNOLD WEISSELBERG

CONSULTING ENGINEERING, NEW YORK, N. Y.

SPEAKING generally, agricultural drying consists in making a product that, although not always of the same color and shape as the original, is capable of retaining its most valuable characteristics as a food or otherwise and can be stored over a considerable time. To justify itself economically, obvious savings in handling and storing costs by virtue of the product's lower weight and volume should not be seriously offset by the cost of producing it. Since we deal mostly with low-priced products, the cost of drying must, of necessity, also be low. The problem is, therefore, one of producing a quality product at low cost.

COST OF DRYING

Costs consist of fixed charges and operating expenses. While the engineer can help reduce the former through cheaper and improved equipment, the resulting saving may be insignificant as compared with that possible by increasing the utility factor. Fig. 1, taken from Circular No. 127 of the United States Department of Agriculture, clearly demonstrates the relation between cost and utility factor. The lowest fixed charges of 1 cent per bu when drying 100,000 bu per year appears to be based on only 200 operating hr out of a total of 8700 hr per year, or a utility factor of only 2.3 per cent which is poor indeed if compared with utility factors for other industrial equipment. How to improve the utility factor is a problem for the agronomist. Diversifying crops and shortening crop cycles are looked upon with favor and should render improvement of the utility factor less difficult. With improved utility factor, lowering of operating expenses becomes all important. Operating expenses comprise heat, power, labor, and maintenance. The last two are the same for drying as for any other kind of processing and need not be dealt with further.

Heat requirements in terms of thermal efficiency are measured in British thermal units per pound of moisture removed, but economic efficiency measures it in British thermal units per pound of dried product. Numerous factors enter into what determines this economic efficiency, the most important of which is the quantity of moisture in the product before artificial drying is applied. Various diagrams are employed to show how much is gained by starting the drying process at a lower moisture content. The one shown in Fig. 2 is novel and appears to be especially well suited to tell at a glance what the gain is. All that is required is a pair of right-angle coordinates, with a decimal scale on either coordinate reading in percentage on a wet basis. If we want to know how much more water will have to be evaporated if we start drying at 75 per cent as against 50 per cent, and the final moisture content to which the material is to be dried is 15 per cent, we draw a slant line connecting 15 per cent on both scales, another connecting 50 per cent on the horizontal scale and 15 per cent on the vertical scale and a vertical line through 75 per cent on the horizontal scale. Then a/b gives the answer, namely, that 3.4 times as much water would have to be removed for the same quantity of dried product if we start drying at 75 per cent as against 50.

Most products of the soil have high moisture contents when they are harvested; forage 70–85 per cent, potatoes and the like 75–80 per cent, vegetables 90 per cent, and so on. Ways and means to accomplish a reduction of this moisture must take into consideration that removing moisture by mechanical means is always cheaper. Of course, we cannot afford to throw away the juices removed by mechanical means as they contain a high share of the nutritive values of the product, but a still cheaper method is to thicken the mechanically separated juices in evaporators at temperatures that will not be harmful to their nutritive value, then return the thick juices to the fibrous material left after separation, and dry them together to the desired final moisture content. The dried product will be just as good and, if the physical change that the product has undergone is not objectionable, this method is one decidedly to be pre-

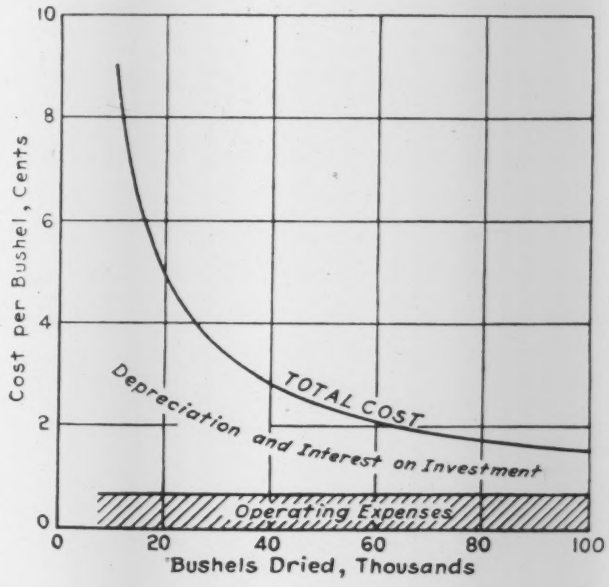

FIG. 1 RELATION BETWEEN COST AND UTILITY FACTOR OF A WHEAT DRIER

Presented at the Agricultural Processing Meeting, New Brunswick, N. J., Feb. 26, 1937, held under the joint auspices of the Process Industries Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, the American Society of Agricultural Engineers, and the Farm Chemurgic Council.

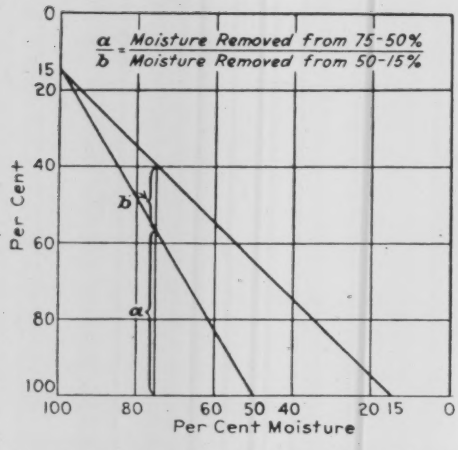
a/b = Moisture Removed from 75-50% / Moisture Removed from 50-15%
Per Cent
Per Cent Moisture
100 80 60 50 40 20 15 0
0 15 20 40 60 80 100
a
b

FIG. 2 GAIN IN ECONOMIC EFFICIENCY RESULTING FROM STARTING THE DRYING AT A LOWER MOISTURE CONTENT

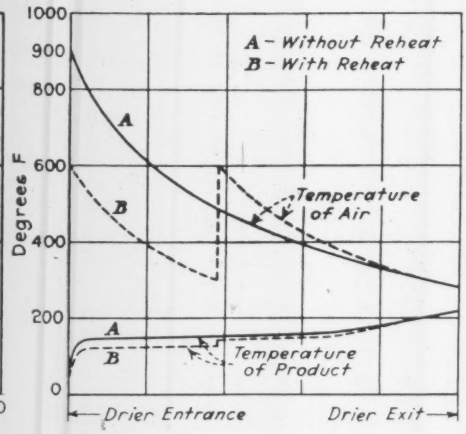

FIG. 3 RELATION BETWEEN THE AIR AND PRODUCT TEMPERATURES

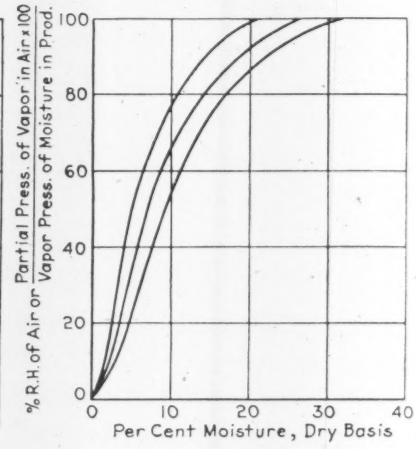
% R.H. of Air or Partial Press. of Vapor in Air x 100 / Vapor Press. of Moisture in Prod.
Per Cent Moisture, Dry Basis
0 10 20 30 40
0 20 40 60 80 100

FIG. 4 EFFECT OF DRYING TEMPERATURE ON THE PERCENTAGE OF MOISTURE REGAINED BY WOOD

ferred. Potatoes, turnips, beets, and similar products, which permit mechanical juice extraction, may be so dried. The economy is considerable, especially on a large scale which permits using concentrators and multiple-effect evaporators to concentrate the juices. In general, moisture can be reduced by mechanical extraction to about 50 per cent and the juices can be concentrated from 95 to 62 per cent of moisture. Based on an initial moisture content of 75 per cent in the green product and reduced to 52 per cent by this scheme, a heat saving of about 40 per cent would result as against drying directly from 75 to 15 per cent.

With many products, extraction of juices is either impossible or impracticable. In such cases, to let the product lose part of its moisture by natural evaporation to the surrounding air before artificial drying is applied, is often advantageous. Most plants will give up a large portion of their moisture in a comparatively short time before any harmful decomposition or deterioration sets in. With average weather conditions, this wilting of forage crops to 60 per cent moisture is possible without impairing quality. By preparation of the product through cutting, shredding, slicing, and the like right after harvest so as to promote rapid wilting, even lower moisture contents can be reached. Much could be done by agricultural-research stations to obtain more data on this important point. For many products wilting is absolutely essential to put the artificial drying of these products on a profitable basis.

SELECTION OF DRYING METHOD

Assume that the moisture has been reduced to the lowest possible point prior to applying artificial drying. Selection of the drying method that is best suited for the purpose requires, besides practical considerations, a good knowledge of the principles involved. Drying is divided into two classes; (*a*) contact drying, where heat is supplied directly, and (*b*) air or gas drying, where heat is carried to the product by air. The former, whenever applicable, has the advantage of lower heat requirements per pound of water removed, 1100 Btu theoretically, and it also dispenses with the power needed in the other to convey the gases. However, the contact that the material must make with the heated surfaces may lead to overheating and damaging the product. As long as the material is wet, the danger from overheating is less, owing to the cooling effect of the evaporating moisture, but with diminishing moisture the temperature of the hot surface and with it the temperature of the material increase. To adapt contact drying to low-cost products that are sensitive to temperature is difficult and costly out of all proportion. Contact drying also requires the product to be in a liquid, paste, or powder-like form, necessitating preparation to which only a limited number of products lend themselves.

Efficiencies of air-drying methods can be quickly compared by means of the water-air mixture chart, devised by the author,[1] from the temperature and humidity of the surrounding air and that leaving the drier. Of course, the heat needed to heat the material and that lost by radiation and convection, also the leakage of air, are not included in computations made on the chart. The fundamental fact remains, however, that the higher the temperature for a certain humidity of the air leaving the drier, the more efficient the drier operation.

Drying temperature is one of the limiting factors, but by drying temperature we understand that of the product itself and not that of the air. We should know the drying-temperature limit for both the wet and dried material. As a rule, the dried material can stand higher temperatures. In the presence of moisture, albumen coagulates at about 135 F and starches gelatinize at about 130 F. Germs and bacteria are destroyed at higher temperatures, 140–150 F, but to allow the product to attain this temperature while it is still wet may do more harm than good. Fermentation and retention of vitamins are both a function of temperature and time. With short drying time, that is, reduced exposure to the oxygen in the air, much higher temperatures can be employed. Vitamins A and C, which are the more sensitive ones, will be preserved below 110 F when the drying is slow, such as occurs on trays that are standing still and with the material in thick layers. With provision for continuous exposure of new wet surfaces and consequential fast drying, 130 F is a safe temperature. In flash drying, the temperature of the product may be as high as 180 F, but provision must be made to cool the product as soon as it is dried. Sometimes a special flavor is obtained by high temperatures, and, everything else being secondary, high drying temperatures can be used.

The fact is still often overlooked that in air drying the temperature of the product is close to the wet-bulb temperature of the air only as long as the product is still wet. As the moisture

[1] This chart was described in a paper entitled "Classification of Drying, Including Graphical Analysis of Air Drying as Developed Abroad," by Arnold Weisselberg, C. W. Thomas, and T. R. Olive, which was presented at a meeting, New York, N. Y., Oct. 18, 1932, of the Process Industries Group of the Metropolitan Section, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

diminishes, less and less evaporation occurs to cool the product and, as a result, its temperature begins rising slowly above the air's wet-bulb temperature as can be seen in Fig. 3, curve *A*. Then at a certain moisture content, which in vegetation varies between 15 and 25 per cent, the temperature climbs quickly, rapidly approaching the dry-bulb temperature. Another important consideration is that, owing to lack of uniformity, considerable variation in the moisture content of adjacent portions of the product may occur, hence the drier portions of the material may become overheated easily or even burned, while the wetter portions are still at a low temperature. Uniformity in the drying operation is, therefore, important, not only from the viewpoint of uniform final moisture in the dried product but also from a quality consideration. As a matter of fact, uniformity of moisture in the dried product is often less important than uniform drying, because when the dried product is stored small differences in moisture tend to equalize in a comparatively short time.

DRIED PRODUCTS REGAIN MOISTURE IN STORAGE

Of considerable influence on the efficiency of the drying process is the final moisture content to which the material is to be dried. As the drying rate slows down with decreasing moisture, the losses increase. Inefficiency due to nonuniform drying is obvious; part of the output would have to be carried below the desired final moisture. For grains and a few other products, final moistures are established and the products are graded accordingly. Information of this kind, is wanting, giving opportunity for fruitful research.

Desired final-moisture content depends on the storage quality that the dried product should have, which will vary according to climate, method of storing, and period over which it is expected to be stored. Whereas some products should regain as little moisture as possible, others should retain this power of regaining moisture or their soaking ability. In the latter case, a compromise must be made between the two requirements and a different method of storing will have to be employed if long storage of such products is expected. Considerably more data on regain are needed than are available at present. Observations and theories that have been advanced on the mechanism of regain would indicate that much benefit could be derived from such data.

That the regain mechanism is more or less nonreversible is characteristic of vegetation, according to the temperature at which the moisture below the hygroscopic point is removed and the time taken for its removal. This is explained by the chemical and physical changes that take place in the cells commensurate with the loss in cellular moisture and the time allowed for these changes to take place. Typical results are reported in the United States Department of Agriculture Bulletin No. 1136, which was issued in 1929, and are shown in Fig. 4. The curves shown are for wood, but we can safely assume that all vegetation behaves similarly. They show that the product dried at 212 F will regain only 21 per cent moisture on a dry basis, whereas that dried at 70 F will regain 33 per cent, if both are subjected to the influence of saturated air or a relative humidity of 100 per cent. They do not disclose the influence of time, but we can assume that at the higher temperature the drying time was shorter. Had it been just as long as for the lower temperatures, the difference in regain would have been larger. We can draw the conclusion that it makes a difference from the regain viewpoint whether the product is shredded or powdered after or before drying, assuming that in both cases the same drying temperature prevailed, since for the latter the drying time would be much shorter. Observations tend to substantiate this behavior, although many more data are needed to prove it definitely.

Rate of regain has been sorely neglected by investigators,

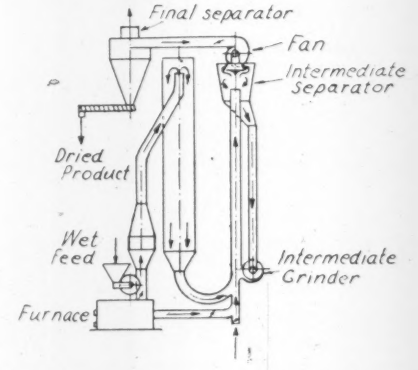

FIG. 5 REMA-ROSIN SYSTEM FOR DRYING AGRICULTURAL PRODUCTS

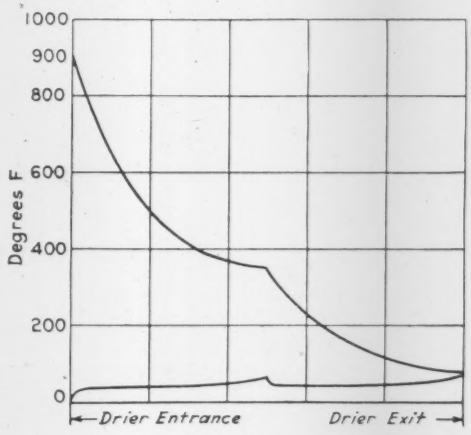

FIG. 7 RELATION BETWEEN AIR AND PRODUCT TEMPERATURES WHERE INTERMEDIATE GRINDING OR SHREDDING EXPOSES NEW WET SURFACES

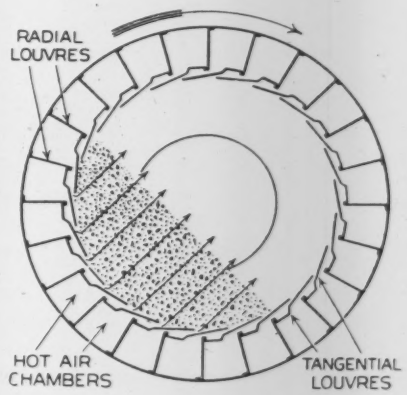

FIG. 11 CROSS SECTION OF LINK-BELT ROTARY DRIER

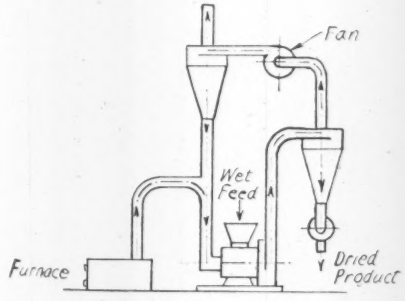

FIG. 6 RAYMOND DRYING PULVERIZER

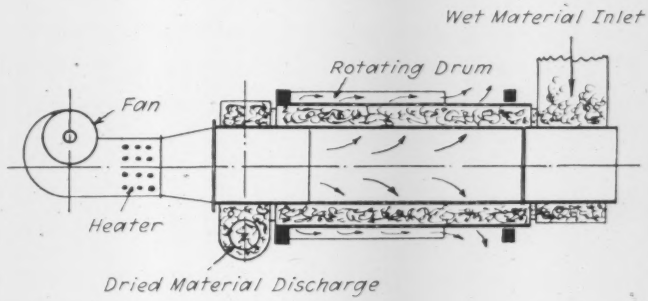

FIG. 8 (LEFT) CROSS SECTION OF THE DESICCATOR, DRIER DEVELOPED IN HOLLAND

although knowing how the regain rate is affected by drying conditions is very important. In some areas where the humidity is high for only a short time, a slow regain rate would be a decided advantage. Products requiring a high soaking ability should have a higher rate of regain. This obviously decelerates as the hygroscopic point is approached. A faster deceleration rate could be offset by drying the product to a lower moisture content, but this would be uneconomical. Observations indicate that fast drying combined with high temperatures results in faster deceleration rates of regain, and the product regains moisture more quickly.

Whether to use parallel flow or counterflow, with or without reheating, to obtain a high efficiency, depends more often on the product than on investing in more or less refined equipment. In general, again, parallel flow without reheating is efficient only if air can be supplied at high temperatures, 600 F and above. It is suitable only for products having a high initial moisture content and calls for provisions that will prevent partially dried material remaining in the high-temperature zone.

Fig. 3 shows the temperature gradient in the drier for the air and the average temperature of the material with one reheating and without. For products with an initial moisture content of less than 60 per cent, reheating is in order as it permits of high thermal efficiencies without high initial air temperatures and consequent danger of overheating or even burning the product. Reheating without zoning retards drying. Consecutive reheating of air flowing counter to the path of the product through the drier will permit much faster drying, all other conditions remaining the same.

Effect of drying time on efficiency is obvious. The longer the drying time, the greater will be the losses. Long drying times also affect the capacity of the drier and with it the fixed and operating expenses. Anything tending to increase drying surface contributes to a reduction in drying time. Also the greater the air velocity relative to the surface, the shorter will be the drying time. Both these fundamental principles must be applied with due consideration to cost and quality. Preparation to increase the drying surface and high air velocities quickly run up costs if carried too far.

Assuming a suitably installed plant of sufficient size to permit of economical operation and drying under conditions such as are usually encountered in agricultural drying, 1000 lb of water can be removed with somewhat less than 1,500,000 Btu supplied with the air, not including fuel-conversion losses, and less than 10 hp for power. For a ton of product dried from 60 per cent to 14, that would be only 3,350,000 Btu and 20 hp-hr. Assuming a fuel-to-heat conversion of 80 per cent, fuel at 24 cents per 1,000,000 Btu and power at 1.5 cent per kw, the cost for 1 ton of dried product would be only $1 for heat and 25 cents for power. Average performance is below this and therefore limits use of artificial drying.

The first question that comes to mind in dealing with this phase of the problem is whether the products should be dried in the field or in a plant that is centrally located with respect

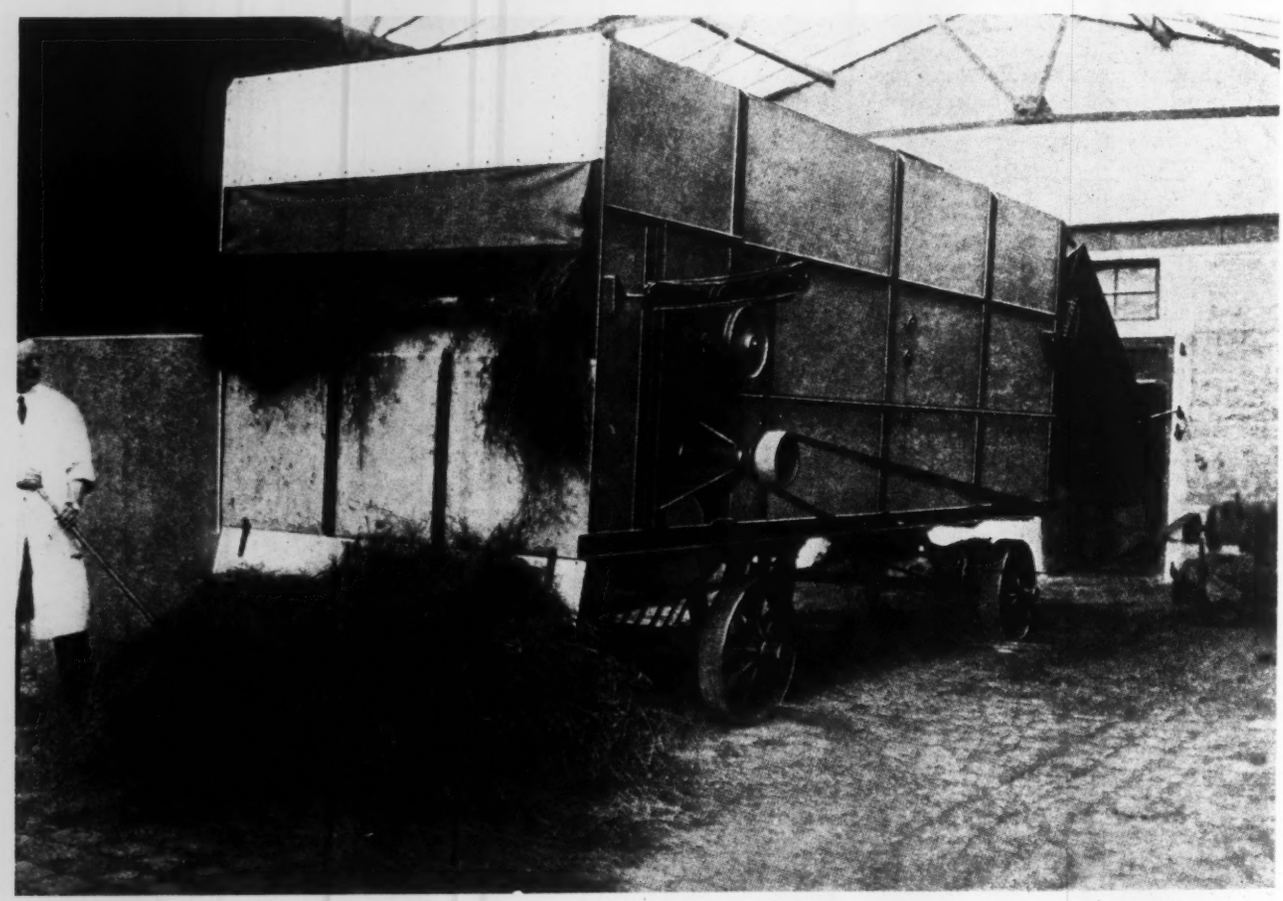

FIG. 9 AN ENGLISH OPEN-BELT-TYPE DRIER THAT OPERATES ON THE COUNTERFLOW PRINCIPLE

to a variety of crops being grown in a given area. Both schemes have their adherents, because each has its advantages and disadvantages. Whatever the preference, portable equipment must be designed along entirely different lines from that for a central plant. Those who are familiar with the literature on field-drying tests or know of them from personal experience may have questioned the wisdom of using equipment that was meant to operate under entirely different conditions.

SUITABLE EQUIPMENT FOR DRYING AGRICULTURAL PRODUCTS

A portable plant must be compact and light in the first place. We must be prepared to make some sacrifice for it. Since heat constitutes the largest portion of the cost, sacrificing thermal efficiency seems less attractive than an increase in power. Fortunately, the great strides that have been made in building Diesel engines and rural electrification make the supply of cheap power less of a problem. With more power we can speed up drying and thereby obtain compactness. To keep resistance to flow at the minimum, streamlining the air passages must play an important part in the design. Where turbulence is needed, streamlining will defeat its purpose. Two methods of drying appear to be best suited for portable-drier design, because of their ability to utilize high air velocity without detrimental effect on uniform drying. Drying the material suspended in air is one; conveying the product between two surfaces permeable by the air is the other. The former requires the product to be reduced to small size so that it can be conveyed by the air at not too high velocities; the latter is suitable for products that cannot be so prepared, at least not in the field.

In Europe, the Rema-Rosin drier, Fig. 5, is representative of the first type, although it is not as yet sufficiently developed to be entirely satisfactory. It differs from the domestic Raymond drying pulverizer, Fig. 6, only in the addition of an intermediate grinder, which permits employing higher initial temperatures or lower initial moistures, as can be seen from a comparison of Figs. 3 and 7. The Trump drier also belongs in this class, although neither has so far been adopted for field service. Representative of the other method is the Hessiccator, Fig. 8, that was developed in Holland and has proved successful for a variety of products. It is a distinct departure from either the rotary or the belt type in which uniform moisture distribution, especially at high air velocities, is difficult to obtain. Fig. 9 shows an open-belt-type machine developed in England. It operates on the counterflow principle with three reheating stages and is $18\frac{1}{4}$ ft long and approximately 7 ft wide and 9 ft high. Evaporating capacity is 500–700 lb of water per hour according to initial and final moisture contents. Optimum fuel consumption is 2500–4500 Btu depending on whether initial moisture is low or high. Power consumption which is also dependent on moisture content ranges from 1.5 to 2.5 kw per 100 lb of water. Its operation, therefore, cannot be classed as economical.

For the small farmer, the portable continuous dryer is beyond his pocketbook. Hence simply constructed portable haystack frames which are placed in the field and on which the forage can be predried by the sun, while the drying is finished by a cheap portable blower and air-heating unit[2] has possibilities. No attempt apparently has been made to employ drying fundamentals.

The central-plant idea has advanced much further in Europe. Drying factories having water-removal capacities of 10,000 lb per hr are operating at high efficiencies. It started in England and other countries are taking it up. For large outputs, the belt type had no serious competition until a few years ago when the so-called turbodrier made its appearance. Its advantage lies in maximum drying area for a given space, which considerably lowers the power consumption. Fig. 10 shows its application to a large central grain-drying plant. In this type, material is transferred and leveled off from one circular shelf to another after one revolution. In another type, for products that cannot stand agitation, a continuous conveyor forms a spiral around the fans, the whole conveyor rotating as a unit, thus greatly reducing the conveying power.

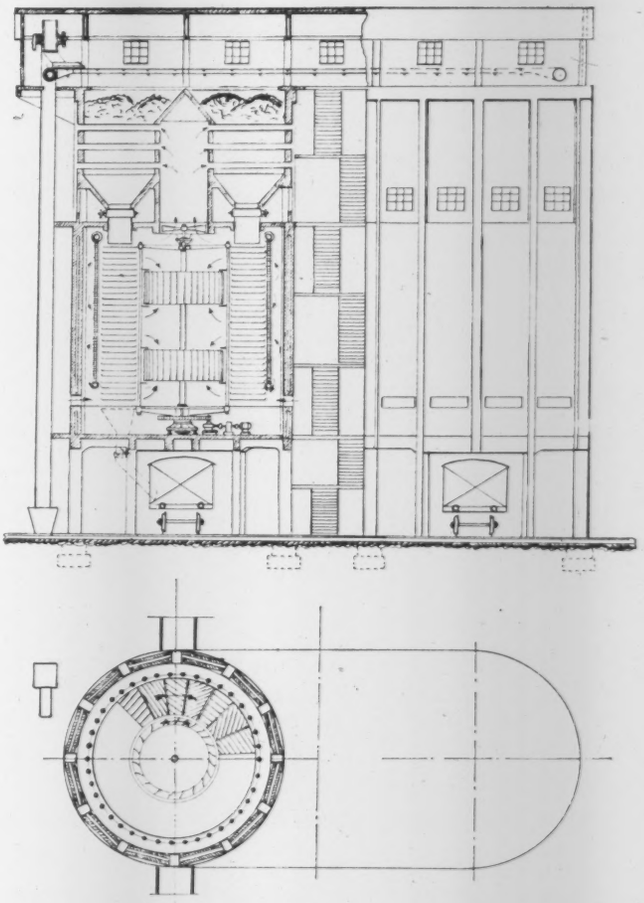

FIG. 10 A LARGE CENTRAL GRAIN-DRYING PLANT HAVING A RELATIVELY LOW POWER CONSUMPTION

Belt driers, of both the simple and the multiple type, have undergone considerable improvement in recent years. Better streamlining of air passages and increased reheating zones have contributed to higher efficiency and increased output. A recent improvement in steam-tube driers, relating to more-positive scraping of the tubes, to prevent overheating, will extend the application of this drier to more-sensitive products which must be quality dried. Application of spray drying to agricultural products is, of course, limited. For low-grade products, the rotary drier will continue to hold its own. A new type that was recently introduced, which appears suitable for better-grade products, is the louver drier. Fig. 11 shows in cross section how the air is circulated. The advantage of this type of circulation is obvious.

The author is convinced, judging from the trend of both agricultural and technical developments, that artificial drying of agricultural products will see great advances in the not-far-distant future.

[2] "The Development of a Low-Cost Hay Drier," by J. W. Weaver, *Agricultural Engineering*, January, 1937, pp. 25–27 and 46.

The Next Step in ENGINEERING EDUCATION

By E. D. AYRES

UNIVERSITY OF WISCONSIN, MADISON

Basing his recommendations on an investigation carried out at the University of Wisconsin, the author proposes ways of broadening the education of engineering students so as to include more economic, social, and business courses by projecting instruction into the period beyond graduation following a four-year curriculum. The proposal recognizes matriculation in the engineering college and professional recognition coming several years after college as the two points in time within which a broadened education would be acquired, and suggests an organized educational procedure made available as residence instruction at the college, correspondence instruction through an extension division, and class instruction by the same means. A list of non-engineering subjects of growing importance to engineers, which might be available under the plan suggested, is included.

ABOUT March, 1935, a careful study was begun to find what should be done at the University of Wisconsin in teaching business and economics to engineers. This study has, in approximately two years, produced some interesting conclusions, whose soundness and simplicity make them worthy of consideration for application on a national scale. Attention has been focused definitely upon the local problem. The college of engineering has always encouraged students enrolled there to avail themselves of the opportunities for broadening their vision and understanding in the humanities through elective work in the internationally eminent departments of economics and sociology of the University. She has, however, never established courses in engineering leading to degrees in administrative engineering, industrial engineering, business and engineering administration, or similar curricula. A department of engineering economics, until recently called the department of engineering administration, however, has sturdily attempted to bridge the gap between technical engineering and business by providing, in the senior year, surveys of the relations between engineering and commerce and guidance to the commercially minded student in making use of his free elective work. Although these facilities have recently been made available for the younger undergraduates, the status of the facilities and opportunities for providing the engineering student with work in business and the humanities has not changed essentially in recent years.

PROJECTING THE ENGINEER'S EDUCATION INTO THE POSTSCHOOL ERA

Close study of the situation at Wisconsin and a scrutiny of educational programs in engineering offered in general in the East and the Middle West against the background of increasing professionalism and the evident need for broader curricula suggests that the time is ripe nationally to project the education of the engineer beyond the end point of commencement day into the postschool period. The new goal, if it can be considered new, should be the achievement of a recognized professional level. The new feature, if it can be considered new, is the development of the idea that the university should take hold and provide educational paths through this postschool period to suit the individual. The idea appears as a responsibility which the colleges of engineering should grasp, because no other agency is so peculiarly fitted to attend to the birth struggles of professionalism for the engineer as is the university and to surround the young infant with comforts drawn out of its stores already developed for its resident instruction, adult education, and alumni and placement work.

In considering a plan for providing education for the engineer in business and economics, at least four definite fundamental premises are immediately encountered:

(1) In the usual four years' college preparation, to expect the average engineering student to emerge with a degree in engineering and also a degree from a school of commerce is impossible.

(2) Engineering schools are primarily interested in turning out men with the proper background for becoming successful engineers; hence, that the engineering student in college emerge at graduation with an adequate education in engineering fundamentals is of first importance.

(3) The present trend toward professionalism in engineering is not likely to diminish in importance in the coming years, and the old importance of graduation from an engineering school as the end of one final stage in an engineer's preparation is overshadowed, or soon will be, by goals pushed forward to several years after graduation in the form of a state license or recognition of an attainment of a professional level by engineering societies.[1]

(4) The engineer has a definite need for an education in business and economics, ranging from the needs of an ordinary citizen to those of a future executive or administrator in industry. In attempting to meet the needs of engineers within such a wide range, any plan for education in these fields must have sufficient variation in the way of optional paths to meet the particular demands and problems of the individual engineer.

Many interviews with prominent engineers and engineering educators over the period given to this study have revealed a growing conviction that courses in engineering must be lengthened to five or even six years. Ultimately, so lengthening the period of resident instruction may be feasible. However, a definite drawback to such proposals exists. Today, many capable engineering students are finding even the term of four years a severe drain upon their economic resources. That

[1] Report of the Committee on Professional Recognition—Annual Reports of the Engineers' Council for Professional Development, 1934, pp. 37–39; 1935, pp. 23–24; and 1936, pp. 25–27.

the idea of lengthening the curriculum can ever be universally adopted in the face of this one real obstacle does not seem possible. Careful development of postgraduate and postscholastic work by the universities, however, can sidestep this obstacle, gain the lengthened curriculum in fact, and, moreover, provide the instruction at a time it can be thrown against a background of the junior engineer's work in industry. Thus, the work can be given to the engineer in the realistic atmosphere and environment of industry, which, for certain purposes, is likely to prove more stimulating and conducive to its appreciation than the college environment.

PROPOSED PROGRAM AT THE UNIVERSITY OF WISCONSIN

The idea that has been proposed for consideration at the University of Wisconsin recognizes (*a*) matriculation of an engineer as a freshman in the engineering college, and (*b*) professional recognition, coming probably several years after college, as the two points in time within which the plan should normally operate. It proposes an organized path with many options to be made available as (*a*) resident instruction at the university, (*b*) correspondence instruction through the extension division, and (*c*) class instruction through the extension division at Milwaukee. Also it proposes that

(1) This plan be called to the attention of students in their freshman year in college.

(2) As much of the work be offered as their individual programs and interests will permit, with the proper degree of guidance in these matters, to undergraduates and graduates in residence in the form of regular college courses.

(3) Any part of the work not taken in college or all of the work, if so desired, be offered in the form of correspondence or class instruction at the Milwaukee center of the University's extension division.

It further proposes that for a definite amount of the work satisfactorily completed by attendance at college, a degree of Master of Engineering and Economics be offered, provided satisfactory arrangements can be made with the department of economics in the school of letters and science; also, for completion of the work partly covered by correspondence and partly by resident instruction at the University or entirely by correspondence instruction, that a certificate indicating the completion of the course be granted.

Such a proposal provides the flexibility that is essential to meet the varying needs of individual students both with respect to course content and availability of facilities to obtain instruction when and where needed. Course content or subject matter to be offered is open to ready change and infinite variation. In addition to business studies, as listed later, the door is wide-open for inclusion of better treatments of such subjects as engineering English and public speaking, advanced technical work, and any amount of cultural work in the humanities.

SUGGESTED COURSE OF BUSINESS STUDIES FOR THE ENGINEER

Study thus far has attempted to focus upon what the author has chosen to call "business studies." The view taken was that in general the engineer is called upon to work for, or with, business units that are already established, the corporation and the giant corporation probably looming over all other types in importance. One of his first and most practical needs is for more technical familiarity with the inner workings and administration of these units so that he may orient his own work properly with other functions of the business which are nonengineering and in most cases financial in character, and that he may develop to its highest level any innate ability he may have to lead others and get along with them in his sphere of influence. Not second in actual importance, but perhaps so in practical importance, he should have a view of social matters to help him understand the significance of his work and that of others so that he may be ever ready intelligently to join forces with, or stand firm against, those social movements which are intended by others to improve society as a whole. The following list of business studies is aimed primarily to furnish the technical familiarity cited first and lay certain foundations for cultural work which may be needed for the latter aim. It is not exhaustive but simply represents an honest attempt to compile a list of studies with which the engineer should have a working familiarity in the main. As submitted to Dean Turneaure in a report dated Sept. 30, 1935, and entitled "An Engineering Economics Department of Instruction for the College of Engineering," the list contained subdivisions which have been omitted here.

* Economic Theory
* Accounting
* Statistical Theory
* Economic Selection and Replacement
* Business Law
* Marketing and Merchandising
† Labor and Personnel Management
† Money and Banking
† Business Organization
† Corporation Finance
Corporate Consolidations and Reorganizations
† Financial and Business Forecasting
Organization for Operation
Cost Finding
Valuation
† Investment and Speculation
† Insurance
Real Estate
Credits and Collections
† Government Finance
† International Exchange

From this list, the six subjects marked (*) were chosen as fundamental introductory studies which should be covered in laying the foundation for any individual plan. Growing out of and closely related to these introductory studies is another group, a large proportion of which should be fitted into any plan. They are marked (†) in the list. In addition to both groups are many special-emphasis groups into which individual interest and a particular professional experience will lead both early and late in the programs of various individuals.

DESPITE COMPREHENSIVENESS, PLAN IS REALLY SIMPLE TO FOLLOW

Inclusion of such a list as that given with the suggestion that avenues be left open for adding cultural and advanced technical subjects is so staggering that the reader is inclined to become lost in its implications and stamp the plan as having no dimensions, no focus, and, therefore, no starting point. If this be a weakness, actual operation of the plan must rise above it, for waving a wand will not make the list disappear and this work, without additions, represents a lifetime task if tackled by the student under his own power by selections of his own from the downtown bookstore.

In the face of criticism concerning its comprehensiveness, the plan settles down to six fundamental subjects as listed, an election of four from the second list of "closely related subjects," and, in addition, six more subjects from the entire list. Such a plan can be operated by orientation courses covering accounting and economic selection and replacement taught by engineers and courses representing the remaining list of subjects taught by economists, sociologists, and other experts. This course can float between the end points, already given, of matriculation in college and the day of achievement of a recognized professional level, using resident instruction, extension-work centers, and

correspondence instruction with only the small teaching contribution mentioned and little other than a strong coordinating influence emanating from the engineering college. That is absolutely all there is to it. To improve it may require simplification and condensation of many subjects, to enrich it may require association of other features, but the curriculum suggested is within the reach of almost any college without much change in course content for subjects now being taught. The idea as a whole once instituted, difficulties arising from so many professions attempting to work together can be ironed out at leisure.

RELATION OF ORIENTATION COURSES TO THE PLAN

As to the relation of orientation courses to the work, in a speech given before the graduate-study conference, held in connection with the annual meeting of the Society for the Promotion of Engineering Education at Madison in June, 1936, the author outlined[2] briefly his opinion on the proper handling of this matter. Present survey courses at Wisconsin are deemed admirably suited for use as orientation courses. They are built around "accounting for engineers" and "economic selection and replacement" as key material. Treatment of either subject by other than an engineer leaves something to be desired which is hard for a differently trained teacher to meet.

Accounting should be treated from the engineer's viewpoint of its use as a methodology or tool, with the specific purpose of covering the field quickly, but with sufficient thoroughness to give an engineer with no previous background a grasp of the subject such that he can

(1) Find and interpret, with confidence, accounting information that he may have cause to obtain directly in the books of any business in his engineering work.

(2) Carry on a conversation with a professional accountant in a business conference, fully understanding the meaning of the many accounting terms and with an insight into the purposes, limitations, and advantages of any particular double-entry system, ranging from a simple set of books to one employing many subsidiary journals and ledgers and embracing many special features.

Economic selection and replacement pertains largely to the "Will it pay?" problem and deals specifically with the selection and replacement of equipment, the preparation of estimates, and certain major aspects of valuation.

Using accounting and economic selection and replacement as vehicles for an orientation course permits presenting extremely important material, while, at the same time, a glimpse down the various paths of study leading out from engineering into business and economics can be given from particularly favorable vantage points. In the orientation course so constructed, the average needs of the engineer in these particular subjects can be covered. To make this point particularly clear, the author wishes to state that intensive preparation for certain executive and administrative work, in all probability, would require some engineers to take further training in accounting taught from the accountant's viewpoint rather than from that of the engineer. The intention, however, is to cover the two fundamental introductory subjects of accounting and economic selection successfully within the bounds of such a course.

COOPERATION WITH INDUSTRY DESIRABLE FOR SUCCESS OF PLAN

The big job is not done, however, once the program for resident and postschool instruction in business studies is operative The inviting opportunity of the university is only niggardly realized if the plan is pushed no further. If the engineer is to be built up professionally with attention to engineering English, advanced technical work, cooperation with state licensing boards, and, as is fondly hoped, with considerable attention to developing the stature of the individual and improving the ethics of the profession, this is a task for the engineering college with as much partnership with industry as can be worked out. Lest this vision be an additional scarehead for the engineering educator who, of all men, is prone to keep his feet on the ground, it should be stated with haste that this vision is the star to which his hopes and aims should be hitched; the building of the ladder into this stratosphere must come with sound and careful measures to insure the success of such an ultimate venture. The college of engineering can start with a modest program of handling business and economics for the engineer and build outward into the postschool area and inward into the resident-instruction area now comprising its own bailiwick.

Digressing slightly from the subject in hand perhaps it nevertheless seems appropriate to point out that, just as economists, sociologists, and other social scientists have their opposing schools of thought, so has the engineering educator in treating the subject of how to meet the engineer's need for greater opportunity in the field of business and economics. One school of men firmly believes that the strict scientific and technical path in engineering is the best preparation for almost any path of life. Extremists in another school advocate the abolishment of schools of both engineering and commerce in favor of "schools of industry." Because both of these ideas are definitely needed to provide the kind of an engineering education that will fit the broad range of candidate aptitudes, modern engineering education is doing both. The eminently technical curriculum is being paralleled by curricula leading to administrative degrees and the like. Such a solution, however, sidesteps the real need. The student with technical strength is neglected while something very definite is being done for the strongly commercial-minded engineering student. The student to be classified in between these two types is getting a laissez-faire treatment which makes for building his stature neither technically nor commercially. Some day perhaps the engineering college will be organized like industry with a vice-president in charge of production and a vice-president in charge of purchasing and marketing. A dean will be used to assume the responsibility for quality of curriculum and standards of instruction as now. Another dean, coordinate in responsibility and importance, will busy himself with quality of the raw product coming to the engineering college from the high schools, development of the personality and professional strength of the students in the educational process, and the marketing of the finished engineering product to industry, and, if the proposal made here bears fruit, with guidance and development of the product leaving the college through the junior-engineer period to a mature professional level.

The curriculum leading to the administrative degree is a fine step in the right direction but leaves the bulk of the engineering product ripe for the guidance and aid which the proposal made in this report will bring. Whether the idea of a floating curriculum meets with the approval of the University of Wisconsin or not, whether the Engineers' Council for Professional Development can see in this plan a sound "going-concern" plan for its professional-training needs or not, whether the engineering societies and industry can approve the extension of the influence of the university into the postschool field or not, the problem will remain, and, ultimately, a plan of the nature suggested seems inevitable as the next step in engineering education.

[2] "Graduate Work in Engineering and Economics," by E. D. Ayres, *Journal of Engineering Education*, October, 1936, pp. 103–105.

INADEQUACY *of the* RINGELMANN CHART

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DETERMINATION of smoke density by comparing the apparent density of smoke as it issues from a stack with a Ringelmann chart located 50 ft from the observer has become almost standard in the United States. The object of this article is to demonstrate that such a comparison does not give any reliable information about smoke density and that the incorporation of this procedure in smoke ordinances either should be abandoned or should be qualified as indicated later. What is written here about the inadequacy of the Ringelmann chart applies in part or in whole to other visual methods for the determination of smoke density.

The first definition of smoke in Webster's New International Dictionary will presumably be acceptable both to laymen and to engineers. It is as follows:

> **Smoke**—The gaseous products of burning organic materials, as wood, coal, peat, tobacco, etc., when rendered visible by the presence of small particles of carbon which finally settle as *soot*. Smoke is thus always the result of imperfect combustion.

"Imperfect combustion" can be accepted as including such phenomena as the thermal decomposition or "cracking" of hydrocarbons which undoubtedly accompanies combustion in many cases and may be responsible for the liberation of soot.

Density of smoke is the weight or volume of soot in each cubic foot of the gases issuing from a smokestack. The common belief that the appearance of smoke is an indication of its density is entirely fallacious. Smoke of a definite density may have any color from light gray to black, depending on the conditions under which it is observed.

FACTORS AFFECTING VISUAL DENSITY OF SMOKE

Darkness or visual density of smoke depends on the amount of light coming through it. If no light comes through it, it is black. Light which penetrates the smoke comes from the background of sky and will vary with the brightness of the sky. The fraction of the light of the sky which penetrates will depend primarily on two factors: true density of the smoke and thickness of the smoke screen. Some other factors that influence the appearance of smoke are the effect of (*a*) wind, (*b*) the presence of steam, and (*c*) reflected sunlight when the sun is behind the observer. In general, darkness or visual density of a column of smoke depends primarily on the first three factors mentioned, brightness of the sky, true density of the smoke, and thickness of the smoke column.

To demonstrate the influence of thickness of the smoke column on visual density, the equipment shown in Fig. 1 was set up in the laboratory of the Brooklyn Edison Company. Smoke was generated by spraying a mist of turpentine over an active fire and the products of combustion were stirred vigorously by a fan in the base of the large cylinder shown in the figure, and were then discharged through the three stacks shown. The actual density of the smoke must have been the same in all the three stacks. A comparison of the visual densities close to the stacks, before dilution with the air into which

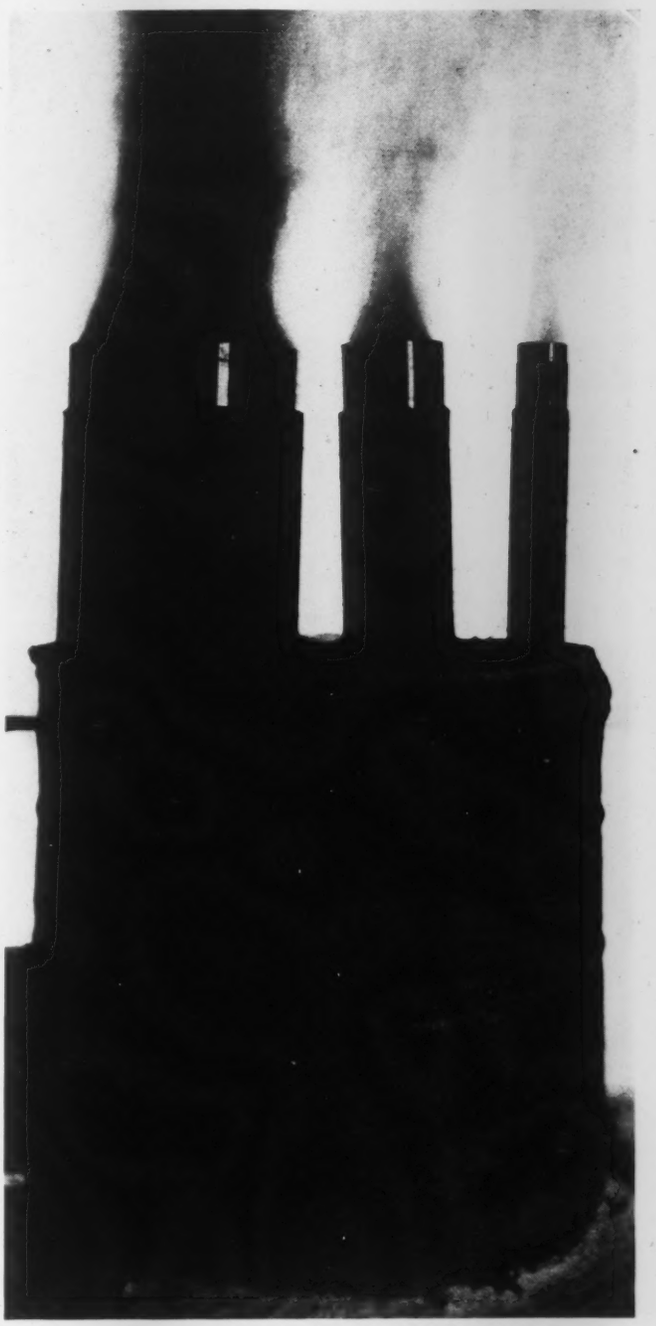

FIG. 1 INFLUENCE OF STACK DIAMETER ON APPARENT SMOKE DENSITY

(Actual composition of the smoke is the same for all three stacks.)

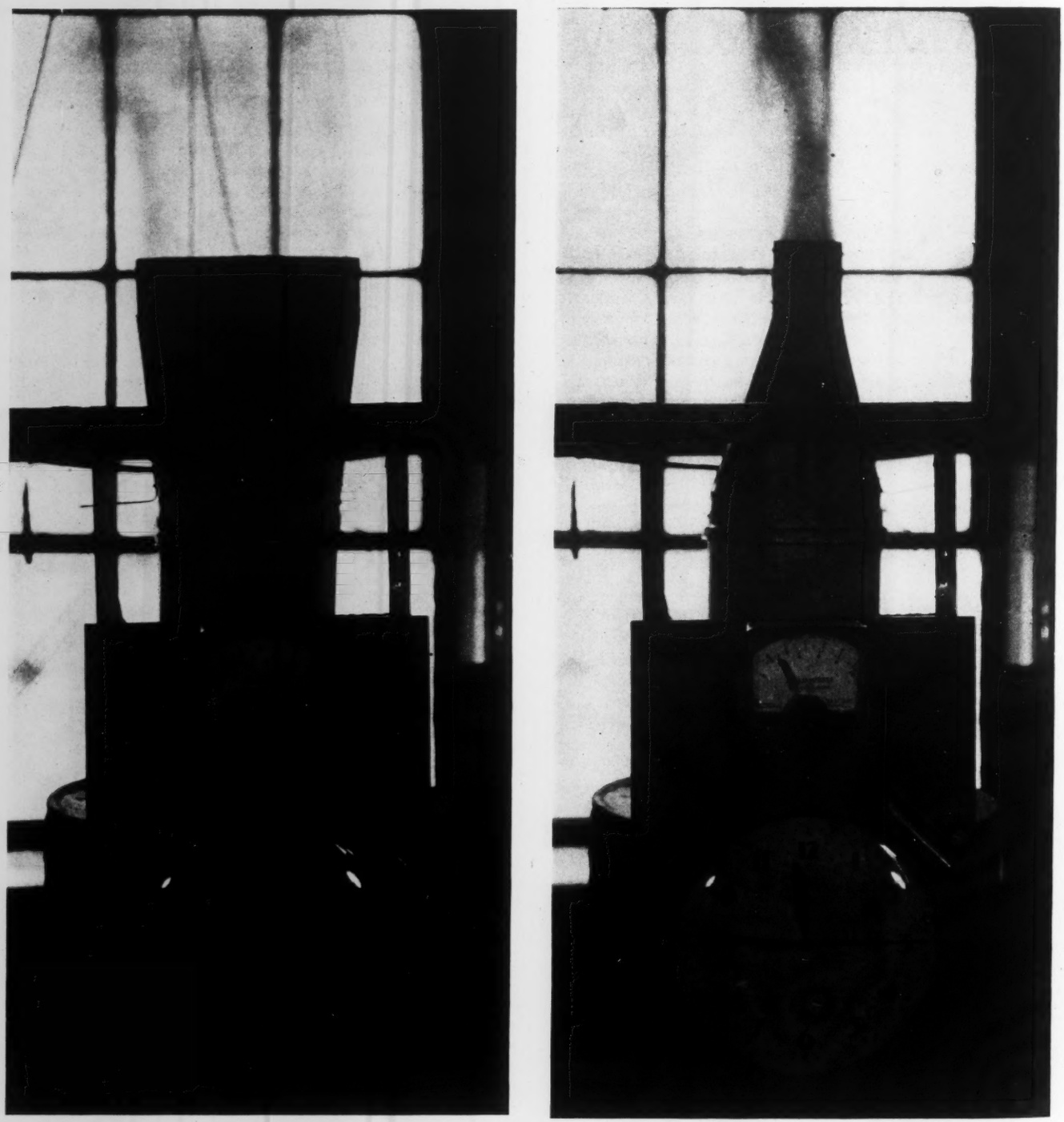

FIG. 2 EFFECT OF THICKNESS OF A SMOKE COLUMN ON THE ABSORPTION OF A BEAM OF LIGHT

(Intensity of the light beam and actual smoke density are the same in both views, but, by rotating the rectangular smokestack through an angle of 90 deg, thickness of the smoke column was reduced from 12 in. in view at left to less than 3 in. in view at right.)

the smoke is discharged, shows a Ringelmann density of 5 for the largest and between 1 and 2 for the smallest stack.

Another demonstration of the influence of the thickness of the smoke column on the absorption of light passing through it is shown in Fig. 2. This demonstration was also carried out in the laboratory of the Brooklyn Edison Company. In this case the density of the smoke was determined by a General Electric photoelectric cell. Light from a source to the right of the smoke column passes in a parallel beam through the smoke to a photoelectric cell at the left of the picture. The intensity of the beam of light arriving at the cell is shown by the indicating instrument located above the clock. The smoke issues through a rectangular stack of dimensions $3\frac{1}{2} \times 12$ in. which is rotatable through an angle of 90 deg. The two photographs of Fig. 2 were taken 19 sec apart and show the instrument indications (*a*) when the light traversed 12 in. thickness of smoke and (*b*) after rotation of the stack through 90 deg so that the light traversed less than 3 in. thickness of smoke. The con-

traction of the issuing smoke stream is evident in the photograph and reduces its thickness below the stack dimensions. The corresponding instrument readings are seen to be about 4 and 1. These can be considered as giving the relative fractions of the light absorbed in the two cases or as measures of the apparent smoke densities.

Another demonstration of the influence of stack diameter on apparent density of smoke uses a "liquid smoke" made from India ink and water. India ink consists of soot, obtained from the thermal decomposition of natural gas, suspended in a liquid. If a few drops of India ink are added to a large quantity of water and the latter is then stirred, the soot will remain uniformly distributed for a long period. Individual soot particles are exceedingly fine—beyond the range of the ordinary powers of a microscope. From the point of view of its constitution this liquid smoke is the equivalent of ordinary smoke but with the substitution of a colorless liquid, water, for colorless gases. As this liquid smoke is used here only for comparative demonstrations, its use is believed to be justified.

Fig. 3 shows four glass cylinders, approximately 1, 2, 4, and 8 in. in diameter. The largest was filled with about 20 lb of water and 15 drops of India ink were added and well stirred. Some of the resulting liquid was then transferred to the other cylinders, as shown in Fig. 3. The white board behind the cylinders was brightly illuminated. The photograph indicates apparent densities of this liquid smoke varying from No. 5 Ringelmann chart for the largest diameters down to about No. 1 for the smallest diameters. The liquid smoke, however, had the same actual density in all four cylinders.

Translated into corresponding chimneys, this indicates that smoke of No. 1 Ringelmann-chart density issuing from a $2^1/_2$-ft stack might appear as dark as No. 5 when issuing from a 20-ft stack. With the same gas velocities, a 20-ft stack handles 64 times as much gas as a $2^1/_2$-ft stack. Consequently a 20-ft stack discharging smoke of No. 5 density could be replaced by sixty-four $2^1/_2$-ft stacks, and in that case the smoke might appear to have a density not greater than No. 1. These demonstrations indicate clearly that a visual determination of smoke density has no significance in terms of actual smoke density unless proper allowance is made for the influence of stack diameter on the apparent density.

Liquid smoke can also be used to demonstrate the influence of the brightness of the sky background on the apparent density of smoke. In Fig. 4, the three smallest cylinders are shown as in Fig. 3 with unchanged contents. The only change is that a gray background is substituted for the upper half of the white background. The influence of this change on the apparent density of smoke is evident. In these cylinders the upper halves of the liquid have apparent densities that are much greater than in the lower halves; in the largest cylinder, which is not shown, no change appears, since in this case all the light is intercepted. This demonstration indicates clearly that a visual determination of smoke density has no significance in terms of actual smoke density unless the condition of the background is determined, as, for example, by a light-intensity meter such as is used by photographers, and proper allowance is made for any departure from a standard brightness of the background.

The effect of wind velocity on apparent density of smoke may sometimes be considerable. On an absolutely still day, smoke ascends vertically with a velocity that diminishes as it rises, in consequence both of cooling and of spreading. Furthermore, cooling diminishes the gas volume and therefore increases the soot content per cubic foot or the actual smoke density. With a brisk wind, smoke is immediately diluted with

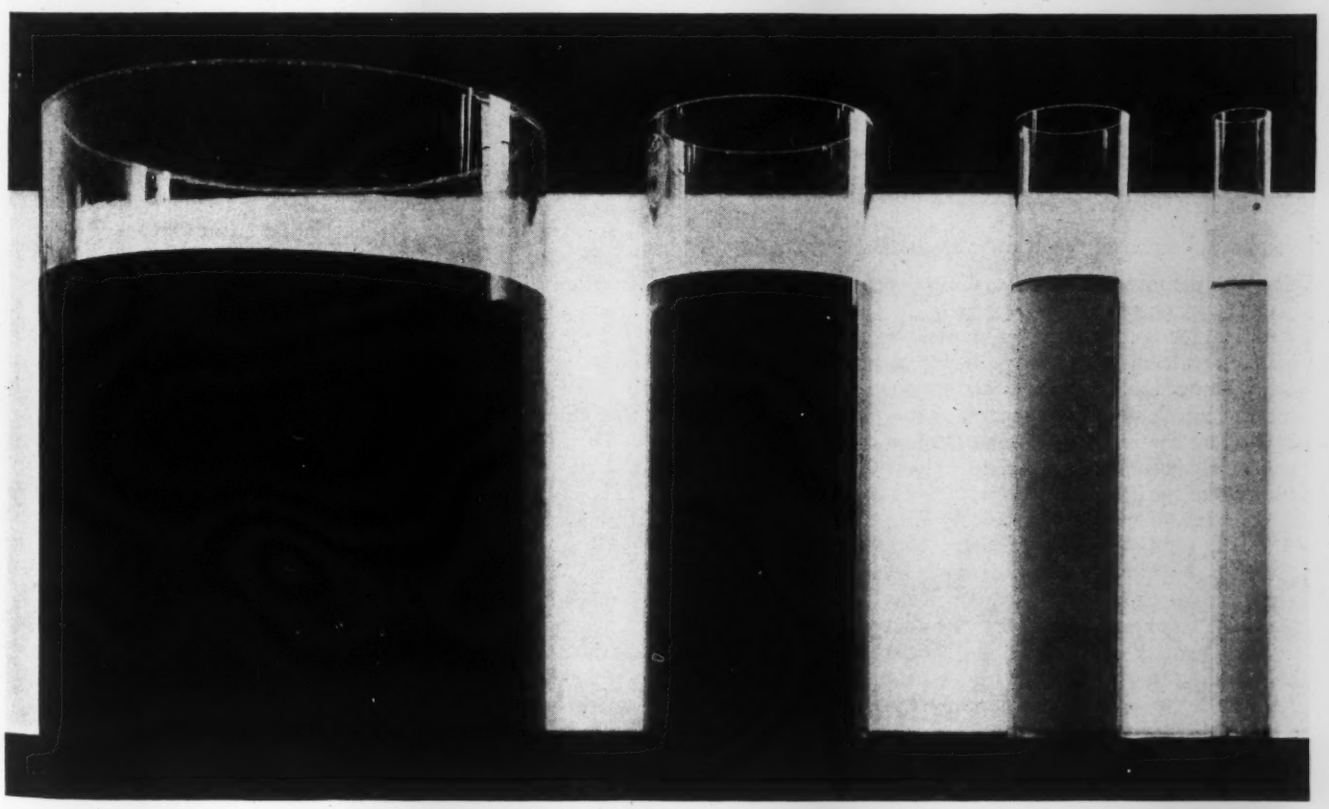

FIG. 3 INFLUENCE OF DIAMETER OF CONTAINING VESSEL ON APPARENT DENSITY
(Composition of "liquid smoke," a mixture of India ink and water, in all four vessels is identical.)

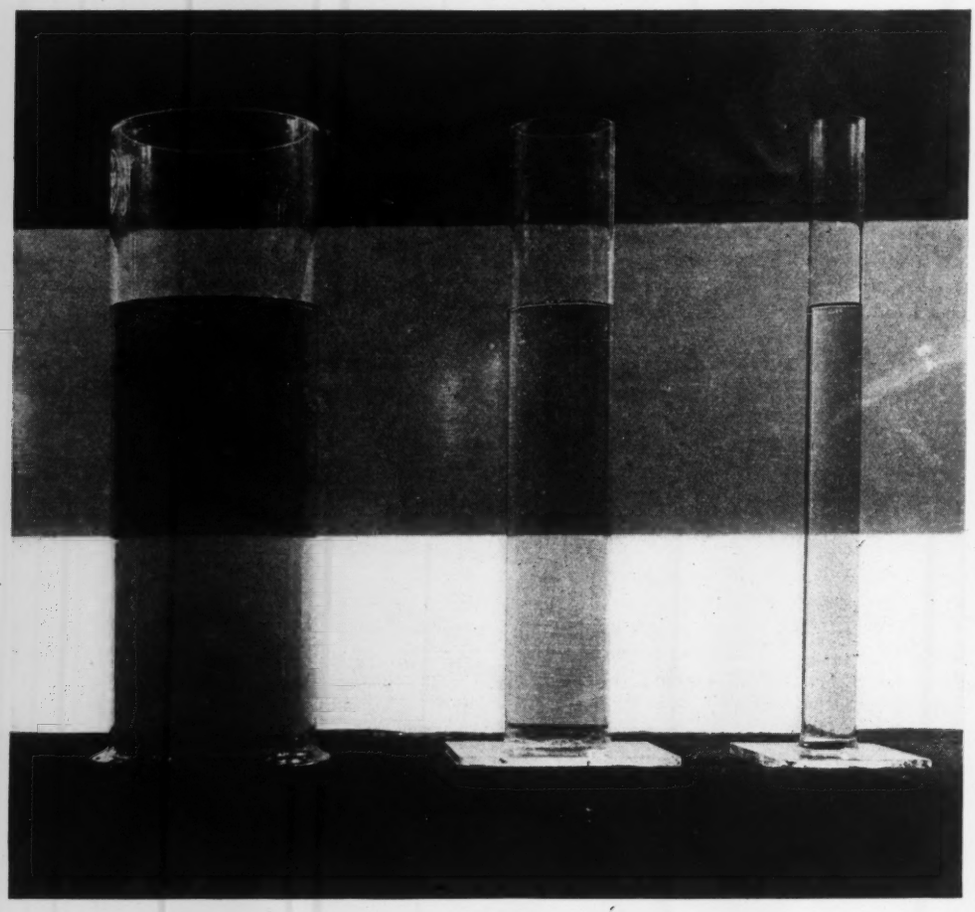

FIG. 4 INFLUENCE OF THE BACKGROUND ON APPARENT DENSITY OF "LIQUID SMOKE"

air on leaving the stack and its actual and apparent densities are diminished. It is evident that smoke issuing from a stack with a given actual density may appear to be very much denser on a calm day than on a windy day.

VISUAL DENSITY THE ONLY CONCERN OF SMOKE ORDINANCES

Smoke ordinances of American cities concern themselves only with the apparent or visual density of smoke. The purpose of the ordinances is to control an assumed menace to health and property resulting from the pollution of the atmosphere by soot. These ordinances do not attempt to control the chemical composition of the gases that carry the soot. Objection can be raised on aesthetic grounds to smoke issuing from a chimney. It can hardly be maintained seriously that the basis of objections by boards of health and other civic bodies to smoke is aesthetic; the basis is always the menace to health and property. Appearance of smoke is not in itself the concern of the smoke ordinances but is assumed to indicate the degree of menace of smoke to health and property.

Existing smoke ordinances do not concern themselves with the total quantity of smoke or soot discharged into the atmosphere in any community or by any plant. What they endeavor to control is the completeness of combustion of fuel and the limitation of the permissible content of soot per cubic foot of chimney gases. As previously pointed out and as demonstrated in Fig. 3, a given total volume of smoke of a given actual density may appear to be dense smoke if it issues from a single large chimney or may appear to be unobjectionable if it issues from a large number of smaller chimneys, although the same total quantity of soot is discharged in both cases. Actually, the smoke from a multiplicity of small stacks would be a greater menace to property, since such stacks cannot practically be made as high as large stacks and consequently discharge their gases at a lower level where the deposit of soot may reach objectionable concentrations as compared with the much wider distribution of soot from smoke discharged at a high level. Limitation of the total permissible quantity of soot discharged into the atmosphere would amount to a limitation on the total quantity of fuel burned in a community or a plant, and no city is likely to limit the industrial activities of its population in that manner.

The immediate objective of smoke ordinances is to prevent the emission of smoke exceeding some definite actual density. This objective is not realized by existing ordinances. Devices, such as the photoelectric type of smoke indicator, will permit a fairly accurate determination of actual smoke densities, but these devices are complicated installations attached to the smokestack or flues and cannot be used by a smoke inspector. A smoke inspector can only make visual observations and this method, it has been shown, is entirely unsatisfactory unless the observations are corrected to compensate for chimney diameter, condition of sky, wind, and other conditions.

THREE OBJECTIONS TO USE OF RINGELMANN CHART

The Ringelmann chart is unsatisfactory, even for the determination of visual density, because

(1) It is inconvenient for the smoke inspector, since the chart should be set up at a distance of 50 ft from him, and this

is often impracticable; (2) it is likely to be misleading since it involves a comparison of the light reflected from the chart with that transmitted through the smoke, and the chart's appearance will depend on its position relative to the sun and on other factors; and (3) it demands judgment on the part of the observer of the comparative darknesses of two widely separated surfaces.

These objections to the Ringelmann chart as a device for ascertaining visual density can be largely eliminated by substituting a device such as the umbrascope,[1] in which the smoke is looked at through an eyepiece while half the field of vision is occupied by a clouded glass or glasses. If the light-absorbing capacity of the clouded glass is equal to that of the permissible smoke, inspection will show at once when the permissible visual smoke density is exceeded. This instrument eliminates the three stated objections to the Ringelmann chart and corrects also for the effect of background on apparent smoke density but does not compensate for stack diameter.

Compensation of observed visual densities for stack diameter must be based on an experimental determination of the absorption of light when passing through a column of smoke of constant density but of various thicknesses. As insuring constant smoke density throughout a series of tests is difficult, these observations can be made on liquid smoke. Such observations have been made for the author in the laboratory of the Brooklyn Edison Company and indicate that, with light from an incandescent-lamp bulb passing through smoke of constant density, the percentage of light absorbed by a layer of unit thickness is a constant fraction of the light arriving at that layer. For example, if light of intensity 10 is reduced 20 per cent, or to intensity 8, in passing through a layer of smoke of unit thickness, then in the next layer of the same thickness the arriving intensity is 8, the reduction is 20 per cent, or 1.6, so that the light will leave that layer with intensity $8 - 1.6 = 6.4$.

The curves of Fig. 5, each of which corresponds to a fixed actual smoke density, show how apparent smoke density changes with stack diameter. Smoke which when discharged from a 4-ft stack has the apparent density 1 on the Ringelmann chart will appear to be of density greater than 3 if discharged from a 20-ft stack; smoke showing density 2 from a 4-ft stack would have an apparent density between 4 and 5 from a 20-ft stack.

A smoke ordinance that prohibits emission of smoke exceeding some stated visual density on the Ringelmann scale will, in effect, make severe demands on plants with large stacks but may be altogether too lenient with domestic or other small stacks. Insistence on a lower actual smoke density for large stacks is justified, since it is practicable in large plants to have high-grade combustion equipment, scientific selection of fuel that is proper for that equipment, and continuous supervision and automatic controls of combustion. But improvement in combustion, and consequent reduction in actual smoke density, cannot reasonably be expected to proceed so far, with increase in size of plant, as to result in no increase in apparent smoke density. For example, if the quantity of fuel burned is increased fourfold, the stack diameter would be doubled for the same stack velocities. With unchanged visual density the actual smoke density would have to be nearly halved.

Complying with very stringent regulations in normal operation of a plant is possible. During operations such as the starting up of banked or of pulverized-coal furnaces, the possibility of smoke is always present, but this need not exceed, either in duration or in actual density, such magnitudes as can be readily tolerated. Occasionally, unforeseeable derangements may occur in an otherwise adequate plant and may give rise to dense smoke; such occurrences should not be penalized, however, if it can be demonstrated that they were truly unforeseeable.

[1] A.S.M.E. Power Test Codes, Instruments and Apparatus, Part 20, Smoke-Density Determinations, p. 10.

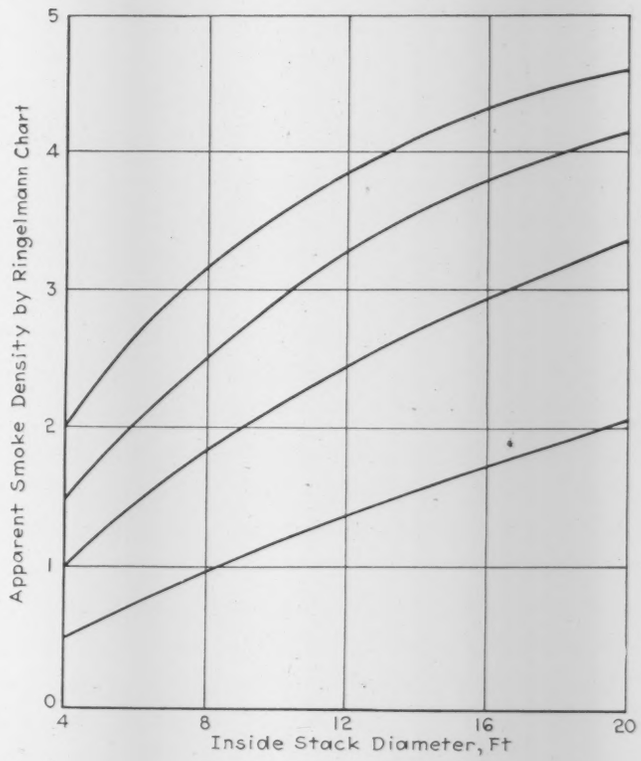

FIG. 5 CURVES OF CONSTANT ACTUAL SMOKE DENSITY, SHOWING VARIATION OF APPARENT SMOKE DENSITY WITH CHANGE IN STACK DIAMETER

A satisfactory smoke ordinance should have characteristics somewhat as follows:

(1) It should insist on a high standard of smokelessness for about fifty-five minutes out of each hour.

(2) It should permit smoke of certain stated visual densities during the remaining five minutes, these permissible densities varying with stack diameter and condition of the sky so as to correspond to attainable actual densities.

(3) The owner of the plant should not be held culpable for exceeding the permissible smoke density if he is able to demonstrate that the smoke resulted from an unforeseeable derangement of a good modern plant which is under continuous expert supervision.

CARBONIZATION of a paste composed of 55 per cent of finely crushed coal and 45 per cent of petroleum, according to a report that was recently issued by the Fuel Research Director, results in the production of a solid smokeless fuel together with oil and gas by-products. In the process, which has been developed by Coal and Associated Industries, Ltd., the coal is completely converted into coke and the quantity of gas produced, 12,900 cu ft per ton of the mixture, is more than sufficient to supply the heat required for carbonization. Each ton of the coal and petroleum mixture produced 55.8 gal of clean crude liquid. The total quantity of refined spirit was 15.7 gal per ton of the mixture.—*The Engineer*, May 28, 1937, p. 617.

Diary of a Search for TRUTH *in* RUSSIA

By OLIN INGRAHAM

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SIR WALTER CITRINE'S book,[1] "I Search for Truth in Russia," is one of the least pretentious and most illuminating of the great library of books written on that subject Save for the introduction and the final chapter it is only a diary of a brief trip to Russia in 1935. At London on the fourteenth of September the diarist embarks on a little Soviet boat. From another little Soviet boat he disembarks on the twenty-eighth of October. Night by night on his trip he writes his diary of what he saw and what he thought. What he writes he leaves unchanged, save for the minimum of prudential omissions—leaves unchanged even if, as frequently happened, what was left contained conflicting statements. Well, with all these "heavy" books published on Russia a diary of a brief trip needs justification.

AUTHOR'S POSITION JUSTIFIES DIARY

It finds justification in the position, the experience, the shrewdness, and the candor of the writer. Sir Walter Citrine was not always a "Sir." He started as a workman—an electrician, worked up through local unionism to national unionism, and finally became the general secretary of the Trade Union Congress which embraces practically all the British trade unions and has a total membership of 4,000,000, roughly equal to the membership of the A. F. of L. but in a country of less than half our population. British trade unions generations ago won their rights to collective bargaining. For that and other reasons they are relatively conservative. The Russian Revolution in its early stages hoped to be world-wide. But labor leaders in Germany, England, and the United States would not join in the revolt. Therefore they were bitterly lampooned by Russian leaders and by their own radicals at home. Sir Walter Citrine has had to bear his share of that lampooning, so though he represents labor, his attitude toward Russia was that of caution and suspicion. That attitude has not hurt the book.

He had visited Russia and conferred with their trade-union leaders ten years before, in 1925. That was before the first of the "five-year plans." He thus had a base for measuring the progress when he came back in 1935 in the middle of the second "five-year plan." He was given the favorable conditions of personal contacts, of a private car, and of the right to be shown everything. He used that right freely. The guides might start in by showing him this or that residence or factory that they wanted to show him. He would insist on driving at random, on pointing out at random this or that home or public building he wanted to see. His eye caught the number 13 at the door of an apartment. He insisted on going in. It was unlucky for the guide, he said. In whatever apartment he went he insisted on wage and rent figures; in any factory, on monthly pay rolls. In short, he could insist on doing in Russia what he could not do in his own country where every Englishman's home is "his own castle."

So he went around free to use a rough method of sampling, free to comment bluntly on deficiencies discovered. As he climbed aboard the returning boat at Leningrad, he was greeted by a Russian leader "who had arrived with a magnificent bouquet for my wife. I said to him, 'After all the criticisms I have leveled at the U.S.S.R., I expected you to arrive with a bomb, not a bouquet.' "

It is a diary, and there is fun as well as thought in the diary. The diary has not gone very far when Sir Walter is searching for the bathtub plug. Thereafter through all Russia he is searching for bathtub and basin plugs. To paraphrase Will Rogers, there was not a bathtub plug in all Russia, or very few.

All through Russia Sir Walter was bothered by and personally bothered with the money system. His belt broke and he went into a Russian store to buy one, and a belt such as he would find in "Woolworth's" was seventeen rubles odd. Now the official exchange was seven rubles odd to the pound. Sir Walter revolted. Of course in Russia international trade other than smuggling is a government monopoly. The Russians had been inviting smuggling by having an official exchange of one value, which made seven and a half rubles to the pound, in spite of the fact that around the corner seedy individuals would solicit Sir Walter's fellow travelers, offering as much as 100 rubles to the pound, a figure which was fairly near its domestic value in terms of commodities. So we find Sir Walter struggling through Russia with astronomical prices and wages high in terms of the official exchange. The extreme of this discrepancy has been reduced since Sir Walter's visit by dropping the official ruble to less than a quarter in value to other monies.

The first effect of the diary is to show that the diary and travel impressions of most people who visit Russia must be of moderate value. They are shown the things they are to see. Sir Walter through his position could demand to be shown what he wanted to see. Between travelers and the things they see is the interpreter guide. One would think that when the Russian government provided a private railroad car for Sir Walter they would provide guides of unusual competence, but the guides themselves and important officials as well gave misstatements which were not so much clever lies as a vague attempt to control the facts. One is forced to wonder as to the quality of the statistics published in Russia, when important members of the personnel of the Russian government indulged in such extraordinary statements as were made to Sir Walter.

CONSTRUCTION AND ORGANIZATION OF LABOR

But Sir Walter's attention is chiefly centered on two things—construction and the organization of labor. As to the layout and general plan of factories he frequently has words of praise. He particularly comments on the excellence of the lighting and ventilation of the great new factories. Of course he was comparing factories, most of which were new, with the older factories of England. But the quality of construction revolts the soul of a former building-trade man. Almost everything

[1] E. P. Dutton & Co., Inc., New York, N. Y., 1937.

One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

seems to him poorly constructed, showing in a few years large amounts of physical depreciation. The Russian workmen have not been made overnight into the careful if slow English workmen.

When he turns to the mushroom growth of new tenements, he finds poor construction, nasty maintenance, and sheer inadequacy of total amount. Many as are the new tenements they are matched or more than matched by the crowds of new city workmen. The populations of Russian cities are growing at a faster rate than Detroit or Los Angeles. To Sir Walter, used to English stability and the solid progress of English housing, especially its splendid development of workingmen's homes in the last 15 years, the Russian housing seemed atrocious. We in the United States are more used to boom cities with overcrowding of laborers which often leads to deplorable standards.

He complained loudly. What would he do, the Russian leaders asked him, when old established cities like Moscow triple their population in ten years and new cities appear on desert wastes? Sir Walter had the English answer, Do not grow so fast, do not transform Russia so rapidly into an industrial country. Possibly we sympathize with the Russians. In some respects they are more like ourselves than the English.

RUSSIAN TRADE UNIONS INSTRUMENTS OF STATE

The part played by labor unions in the organization of labor had to seem topsy turvy, of course, to Sir Walter. He was a representative of unions which have had the longest experience of steady collective bargaining of any country. Long experience turned into tradition. Traditional methods became property rights which the union defended. Behind that defense the Englishman carried on in his slow steady way. But Sir Walter found that trade unions in Russia were simply instruments of the employer, which is the state. The employer's chief preoccupation was to expand output. The trade-union leaders as good communists had to help in such expansion, had to encourage speeding up, scientific management, and nationaliza tion. Former methods of doing things had no rights. Because they were "former," obviously they must be wrong. The noise and rush found in some of the Russian factories offended Sir Walter's senses. Also he found a good deal of scientific management that was not really working. It was hard even under communistic stimulus to transform the workmen. He goes back to one of his early experiences: "Years ago, when I was an electrician, we installed electrical pyrometers in a glass factory to tell the furnace man when the exact temperature had been reached for them to cast the glass. Whilst the experts were there these methods were followed. Immediately their backs were turned, the men stuck a raw potato on the end of an iron bar and thrust it into the furnace. Then they drew it out, and breaking it open, decided whether the right temperature had been reached."

But the Russian management did not depend on communistic suasion only. As far as possible wages were determined by piece rates. Piece rates depended on norms of expected output and, as factory managers told Sir Walter, these norms would be raised and raised. In short, there would be the same piece-rate cutting which in the United States have made unions attempt to destroy or control piece rates. But in Russia the unions watched this process with approval. Besides the steady stimulus of piece rates there were bonuses, prizes, and great vacation trips to the Crimea, there to dwell in what were once the palaces of czaristic Russia.

Besides the differences in pay for differences in amount of work, there had grown up the differences in pay for differences in qualitative capacity. In a country with too small a proportion of skilled workers the cash stimulus was used for the encouragement of the achievement of skill. In the factories, workers were classified into eight categories, workmen in the eighth category receiving about three times as much as those in the first. The workmen at any time had the right to demand an examination as to whether their category should not be raised and a right to appeal from the decision of their local factory. Of course, this three-to-one ratio does not take in the higher pay of work managers, and so on. Their pay may be many times that of the workmen.

FACTORY A REAL CENTER

The Russian factory is the center of other things than work. It has to provide the nursery for the babies of the women workers. At the time of Sir Walter's visit it provided stores open only to its workers where prices were lower than on the outside. This system is in the process of being abolished. The factory also provided some of the meals, and I was glad to notice in Sir Walter's diary that the head cook received two or three times as much as the workmen. And of course the factory is the unit for the comprehensive system of social insurance in Russia administered by the trade unions. Sir Walter estimated that the total given to the workman outside of his wages might amount to a third of his wages. On the operations of most of these social-reform characteristics of modern Russia, Sir Walter's comments were friendly.

So leaving out profits and dividends, the general schemes of stimuli to production, of graded pay, of supplementary welfare do not seem to be very different in Russia under the name of communism than they are in America under the name of enlightened business. Of course, the whole level of real incomes is very much lower in Russia, owing mainly to inefficiency but partly to the larger percentage of labor devoted to the future and to the greater proportionate cost of preparing for war, which have to be subtracted from the real wages of the present.

Developments and Problems of Aircraft Engines

(*Continued from page 670*)

engines. Perhaps radical changes in design and materials will have to be made in reaching out for the higher power, but without question the designers with all the ingenuity and skill that they have already shown in reaching the present stage will likewise be able to overcome the future obstacles as they present themselves.

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BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context, and credit to original sources is given.

In the News

DURING the past month aviation has had its ups and downs in the news. With the abandonment of the United States Navy's search for Amelia Earhart and her navigator, lost in mid-Pacific, has come the report that much valuable information was acquired. It is said that the search helped to correct charts, permitted a cursory survey of the area, and provided an opportunity for 4000 Navy men to study 250,000 sq miles of the earth's surface in the vicinity of Howland Island and the weather and operating conditions in a part of the Pacific Ocean that is becoming important for strategic reasons. Naval planes and ships traveled 180,000 miles in a 17-day search.

AIRPLANE TRAGEDY AT SEA

Another airplane tragedy at sea was reported in the finding of the wreckage of the Pan American-Grace Airways flying boat, due at Cristobal, Canal Zone, on the evening of August 2, approximately 20 miles from its destination. The practically new Sikorsky S43 two-engine high-wing monoplane with a span of 84 ft and a cruising speed of 167 mph met bad weather conditions and when last reported was spiraling down through the clouds. Evidence of an explosion was found in the wreckage, but no trace has yet been found of the cabin and its 14 occupants. Although this is not the first fatal accident of the Pan American-Grace Airways, it is said that in eight years, with 200 million passenger miles of flying, the parent Pan American line has suffered no loss of life.

$5,000,000 FOR AIR-NAVIGATION AIDS

In view of the numerous airplane accidents of the year and criticism of the inadequacy of aids to aerial navigation in certain parts of the country, the Bureau of Air Commerce announcement that $5,000,000 is to be spent on improving such aids and setting up new facilities is important. It is reported that in the program is the adoption for Bureau radio stations of simultaneous transmission of both voice and signals so that while radio signals are being sent continuously to keep the pilot on his course, voice broadcasts may be made from time to time on the same frequency.

RUSSIANS COMPLETE TWO TRANSPOLAR FLIGHTS

Continuing with the brighter news of aviation, the flights of the Pan American Airways and Imperial Airways planes across the North Atlantic, preliminary to the establishment of passenger service, and the two successful transpolar flights from Moscow to the Pacific coast of the United States are achievements of a high order and reflect genuine progress in heavier-than-air flying. The second transpolar flight set a nonstop long-distance record of 6262 miles, breaking the previous record of 5653 miles from New York to Syria set by Rossi and Codos in 1933. The Russian plane's flying time was 62 hr and 2 min, of which 56 hr was in daylight. The plane which made this record flight was built in 1932.

A NEW ARMY FIGHTING PLANE

The United States Army's new fighting planes got into the month's news also, with the announcement of a new Army fighting plane designed to replace the pursuit single-seater. It carries a crew of five, six machine guns, and bombs, has a speed of 300 mph, and can operate at 30,000 ft. The two Allison 1000-hp engines of the machine, which was built by Bell Aircraft of Buffalo, are located in nacelles on either side of the pilot's cockpit and drive propellers of the pusher type. There is a separate power plant for lights, radio, starters, and retractable landing gear.

"AERIAL SUBMARINE" FLIES TO WRIGHT FIELD

Newspapers of August 3 reported the arrival at Wright Field, Dayton, of another high-altitude army plane from the factory in California. It has been termed an "aerial submarine" because of its hermetically sealed cabin. This cabin is divided into two compartments, one of which can be used as an air lock. Separating the two compartments is a bulkhead provided with an airtight door fitted with a window. Almost sea-level atmospheric conditions can be maintained in the entire cabin at altitudes up to 6 miles, and it is possible to maintain different air pressures in the two compartments when the bulkhead door is closed. Turbo superchargers driven by exhaust gases maintain the sea-level air pressure in the cabin. The superchargers are double units, one furnishing air to the engines and the other air to the cabin. Reserve oxygen tanks are carried. The maximum altitude flown on the trip from the Pacific Coast was 25,000 ft and it is said that cabin pressure was never less than that at the 13,000-ft level. Temperature in the cabin was never below the comfort level. High-altitude ships are said to be able to fly above the range of antiaircraft guns and to be independent of attack by pursuit planes not equipped for stratosphere flying. The cruising radius is also increased because of the lower resistance to flight in the rarified atmosphere at high altitude.

PICARD GOES UP AND COMES DOWN

Lighter-than-air aviation got public notice through the unsuccessful ascension of Jean Picard's novel balloon *Pleiades*. Picard ascended at Rochester, Minn., to a height of 11,000 ft in a balloon consisting of 2000 small balloons of the type used for meteorological studies. Trouble ensued. The balloon came down near Lansing, Ia., and was destroyed by fire. Picard was unhurt. He is reported to have said that he had trouble with some of his balloons "so I took my pistol and killed about a dozen of them. Then I came down."

ST. ELMO'S FIRE BLAMED

Another chapter in the disaster of the *Hindenburg* appeared in the form of the report of the special committee of the Depart-

ment of Commerce. The cause of the accident was said to be ignition of a mixture of free hydrogen and air, evidence pointing to a leakage of hydrogen in the vicinity of cells 4 and 5. A combustible mixture formed in the upper part of the ship in considerable quantity and open flame first appeared on the top of the ship a relatively short distance forward of the vertical fin. The theory that a brush discharge ignited the mixture is said to be most probable. Dr. Hugo Eckener is reported to have said that the report findings coincided with his own theory.

OPINIONS ON AIRSHIPS DIFFER

Before the House Committee on Naval Affairs opinions differed as to the value of dirigibles. Assistant-Secretary of the Navy Charles Edison, Admiral H. B. Cook, chief of the Navy's Bureau of Aeronautics, and Commander Charles E. Rosendahl urged the building of a new dirigible, but Admiral W. D. Leahy, chief of Naval Operations, said that the Navy had found the airship "wanting."

Admiral Cook told of plans for a 10,000,000-cu ft airship to carry nine bombing planes weighing 10,000 lb each when loaded, thus putting the dirigible in the aircraft-carrier, rather than the scout, class. The airship would be able to cruise at 60 to 70 mph with a cruising range of 15,000 miles. Admiral Cook said that to construct seven such airships would cost as much as one surface-ship carrier which would transport as many planes.

ENGINEERS HELP YACHT RACING

Two members of The American Society of Mechanical Engineers, Zenas R. Bliss and Kenneth S. M. Davidson, have been in the news about the international yacht races. Professor Bliss acted as navigator of the *Ranger*, a position he has held in previous races. Professor Davidson, in a towing tank described in his paper to be found in the A.S.M.E. Transactions, *Journal of Applied Mechanics*, June, 1936, conducted the model tests for the *Ranger's* designers. W. Starling Burgess, who in collaboration with Olin Stephens designed the *Ranger*, describes the hull-model tests made by Professor Davidson at the Stevens Institute of Technology. Mr. Burgess says that "the model selected was so unusual that I do not think any one of us would have dared to pick her had we not had the tank results." All in all the *Ranger* is a scientific and engineering triumph, as well as a racing triumph in the hands of her skipper.

"WEATHER EYE" ON WHITE FACE

Extension of meteorological service was announced in the establishment on White Face Mountain in the Adirondacks, in the State of New York, of a "weather-eye" observatory as a joint project of the Weather Bureau, Rensselaer Polytechnic Institute, and New York University. Its purpose is to assist air lines and farmers, and to add to meteorological knowledge of solar radiation the relationship between weather and air masses and runoff and evaporation. In this connection see the paper on weather forecasting by Irving Krick in the August issue of MECHANICAL ENGINEERING.

NORMANDIE BREAKS RECORDS

The *Normandie* arrived at Ambrose Light at 11:59 p.m. Sunday, August 1, after a record voyage from Bishop's Rock of 3 days, 23 hr, and 2 min; average speed, 30.58 knots. She also set an all-time record for a westbound run in one day of 781 miles at an average speed of 31.24 knots. A Hollywood star is said to have been pleased with the record but annoyed at having been awakened earlier than usual to disembark. The *Normandie's* eastward crossing on her return trip also broke a record. Her time, Ambrose Light to Bishop's Rock, was 3 days, 22 hr, 7 min; average speed, 31.2 knots over 2936 nautical miles.

R.P.I. TO GET $5,880,000

By the will of Mrs. Cora L. Cogswell, widow of W. B. Cogswell, R.P.I. alumnus, two trust funds amounting to $5,880,000 have been left to Rensselaer Polytechnic Institute. A report in the *New York Times* for July 15 says that there are no restrictions on the use of the funds, but that Mrs. Cogswell's sisters are to enjoy the income for life. Mr. Cogswell was one of the founders of the Solvay Process Co.

PLANNING TO TAKE CURSE OUT OF INVENTIONS

On July 18 the Subcommittee on Technology of the National Resources Committee released its 450,000-word report "Technological Trends and National Policy, Including the Social Implications of Inventions." The report deals with new inventions and their social implications and calls for planning to meet the new situations caused by technological advance. It suggests a federal committee whose responsibility it would be to keep abreast of technological changes and to forecast imminent changes that may affect national life. Metropolitan press comments in general were not enthusiastic, but the section on "Power," written by A. A. Potter, past-president of The American Society of Mechanical Engineers and president of the American Engineering Council, was favorably received.

NEW YORK CODE PERMITS WELDING IN TALL BUILDINGS

Mayor La Guardia, of New York, on July 27 signed a new building code for the City of New York, which had been passed by the Board of Aldermen a week before, after waiting four years in committee. The code was sponsored by the Merchant's Association, and for the first time permits fusion welding in the framework of tall buildings. Gilbert D. Fish, chairman, American Welding Society's Committee on Building Codes, said in comment: "Besides being quiet, welding has other advantages when used in steel construction. It makes possible stronger, stiffer joints, and often effects a considerable saving in the amount of steel required." There are said to be 200 welded buildings in the United States, a number in Europe, and a few elsewhere.

WATER SUPPLIES TAXED BY AIR-CONDITIONING

Concern over the widespread demand upon the water supplies of many municipalities as a result of the increasing number of installations of the type of air-conditioning apparatus which discharges water into sewerage systems is felt by many officials, according to a report of the Marketing Research Division of the Bureau of Foreign and Domestic Commerce, recently released. The situation is said to be particularly acute in Chattanooga, Atlanta, Columbus, Ohio, and South Bend, Ind., where the present facilities are being used to their "full capacity." In a study of 92 cities of more than 100,000 inhabitants it developed that 38 have already taken steps or plan action to limit the use of water-consuming air-conditioning equipment.

PUTS IT UP TO ENGINEERING COLLEGES

Speaking at the Ninth Annual Institute of Rural Affairs, Virginia Polytechnic Institute, Blacksburg, Va., late in July, David E. Lilienthal, TVA director, is quoted as saying: "The TVA was designed as an experimental proving ground for the nation, with a national point of view, financed by national funds, with the results available to the whole country. Is it

too much to expect that before long it will have become a national policy for us as a nation to assign engineering colleges, with federal support and coordination, a responsibility to aid in increasing farm income and bringing diversification to our agricultural regions?" He also predicted that new and inexpensive refrigeration units would increase farm prosperity. [On a visit last spring to the University of Tennessee we were privileged to see some of the work being done in this type of refrigeration.]

RADIO PIONEER DIES

On July 20 Guglielmo Marconi, inventor of wireless telegraphy, died of a heart ailment. It will be recalled that after Marconi first succeeded in transmitting signals across the Atlantic Ocean, Calvin W. Rice, former secretary of The American Society of Mechanical Engineers, was so impressed with the accomplishment and so enthusiastic about the possibilities in communication that it opened up that he arranged for a dinner in honor of the inventor in New York. Mr. Rice used to take modest pride in reminding his friends that only with difficulty was he able to round up enough persons to make the dinner worth-while.

THEY HAVE A WORD FOR IT IN U.S.S.R.

Harold Denny, *New York Times* correspondent, in a dispatch from Moscow, July 28, says that the Kremlin is trying hard to reassure honest executives and engineers who lost morale as a result of the recent "purge." Honest engineers, he says, have been called upon to rally to bring industry up to par, and it is officially pointed out that "in the second quarter of the year only a fourth as many engineers had been tried as criminals as in the first quarter." It seems that "spikoteklinoka," which Mr. Denny translates freely as "passing the buck," is considered a disgrace to engineers and is suspected as having been devised by enemies to popularize the avoidance of responsibility, with consequent confusion in industry.

YOUR LIFE'S WORK IS WORTH $95,300

Harold F. Clark, in charge of Educational Economics, Teachers College, Columbia University, caused some engineers to raise their eyebrows when he presented, in July, a table of working-life span and present value of the average earnings of that life span in selected occupations in the United States. Engineering comes fourth in the list with a working-life span of 43 years and a present value of average earnings for that span of $95,300. Medicine tops the list, at 42 years, $108,000, followed by law and dentistry. College-teaching figures are 44 years, $69,300; skilled trades, 44 years, $28,600; and farm labor (last) 51 years, $10,400. The amounts mentioned are explained as being what a banker could afford to advance to the average individual at the beginning of his working career on condition that he promises to surrender all of his earnings for life. The compound interest is figured at 4 per cent.

SOCIALIZING THE PROFESSIONS

As a first step toward making good his prediction to the medical profession at its recent convention in Atlantic City of federal licensure based on the theory that the doctor is a federal auxiliary, Senator J. Hamilton Lewis, of Illinois, introduced a resolution into the Senate on July 28. The proposal requires all physicians, surgeons, and hospitals to care for impoverished individuals at "reasonable and just" charges, to be paid through the Social Security Board. The measure would make all physicians and surgeons practicing in the United States and its territories "civil officers" of the government for the purposes of the resolution.

Industrial Psychology

JOURNAL OF THE ROYAL SOCIETY OF ARTS

INDUSTRIAL psychology is a misnomer, according to Charles S. Myers, principal, National Institute of Industrial Relations (Great Britain) in an address published in the *Journal of the Royal Society of Arts* for April 30, 1937. Industrial psychology, he explains, means the study of the human factor throughout occupational life. It is applicable, he continues, even before the start of occupational work, since by vocational guidance it aims at determining the most suitable career for the young person who is about to choose his life's work. Even earlier, by educational guidance, it helps to advise as to the kind of education for which the adolescent is innately best fitted. In vocational selection the object of industrial psychology is to choose the best of the applicants for a vacant occupational post. Industrial psychology is closely concerned when the novice comes to receive training in his future work, and it enters in improving industrial relations and personnel management and in bettering general working conditions. It relates not only to every kind of productive work and worker but also to the distribution of goods and to the study of the consumer.

Dr. Myers then reviews the origins of industrial psychology in Great Britain, after the war and of the National Institute of Industrial Psychology.

Turning his attention first to educational and vocational guidance, Dr. Myers says that the striking success achieved is the result of an "all-round" view and systematic procedure. The industrial psychologist aims at a full knowledge of the young person's abilities, temperamental and character qualities, physique and constitution, and also of the extent to which these are required for success in different occupations. He does not neglect interests, ambitions, or opportunities. His general practice is to indicate the three or four most suitable kinds of occupation and to discourage the choice of others wholly unsuitable.

Methods of vocational selection, according to Dr. Myers, can be made more reliable by determining and realizing beforehand what qualities are required for success in a vacant post, by framing questions at an interview so as to ascertain these qualities separately and assessing them separately on a prescribed scale, by asking definite and relevant questions of those competent to testify to the suitability of the applicant, and by recourse to appropriate tests that will afford some measure of abilities possessed by the applicant which are known to be necessary for success in his new work.

In vocational training, Dr. Myers points out, industrial psychology has come to play an important part in the selection of suitable teachers, in the determination of the best movements and other methods of work which should be taught, and in the best ways of giving such instruction. Man is not to be treated as an animal, he says, trained mechanically to perform one particular trick. Under modern industrial conditions processes are continually changing, and unless the worker has been instructed in the general principles underlying his work, he cannot be expected to face changed conditions without initially wasting effort and incurring needless fatigue.

In so far as working conditions are concerned the industrial psychologist studies such problems as mental work, fatigue, and boredom, the acquisition of skill, the causes of accidents, and the provision of the appropriate incentives to work. The relation of optimal occupational efficiency to lighting, ventilation, and temperature, to noise and vibration, to food and

periods of sleep and rest, and the determination of the best mental as well as physical conditions for work-a-day life, and for the use of leisure fall within his province.

Dr. Myers concludes with some observations on industrial relations and personnel organization, dealing briefly with such topics as the impossibility of an employer's knowing personally all of his employees, his function in maintaining *esprit de corps*, suggestions from workers, causes of absenteeism, and the advantage of employing a visiting industrial psychologist.

A Problem in Education

ELECTRICAL ENGINEERING

FOR several years mechanical engineers have looked to one of their own number, Ralph E. Flanders, past-president of The American Society of Mechanical Engineers, for thoughtful analyses of the social and economic implications of the engineer's function and influence. As wisely perhaps as any other's Mr. Flanders' voice has been heard calling upon engineers to think on the important questions involved in their relationship and obligation to society. Sanity, sound judgment, "realistic idealism," if the term may be used, and sincerity have characterized Mr. Flanders' frequent utterances, and his experience as an engineer and an industrialist has provided both the foundations of his philosophy and the common ground upon which he stands with fellow engineers sharing his enlightenment and concern for our industrial civilization. His deep-seated faith in our ability wisely to chart our course toward an attainable objective has bolstered many with flagging enthusiasms and confusing doubts. This objective he expressed in the first progress report of the committee on economic balance of the American Engineering Council: "The selection and recommendation of such governmental, financial, and business policies as will maintain in the United States a standard of living that is high, broadly distributed, and free from severe fluctuations."

In the August, 1937, issue of *Electrical Engineering* Mr. Flanders' address on "The Engineer in a Changing World," delivered at the 1937 summer convention of the American Institute of Electrical Engineers, is to be found. This address was a companion to that by Dean Vannevar Bush, of M.I.T., from which sections were quoted in these columns last month, pages 615 and 616. In a portion of Mr. Flanders' address devoted to the engineer's responsibilities to the public, he said:

Doctor Vannevar Bush has analyzed the social responsibility of the organized engineering profession with particular reference to its relation with government: I am going to suggest the nature of our responsibilities to the general public. We are now engaged in a strenuous race, a race between education and the breakdown of democratic government. As one of its major resulting catastrophies the breakdown of democratic government would destroy the engineer's usefulness to society and put an end to all reasonable hope for a continuation of our old progress toward a higher standard of living for the mass of our fellow citizens. To forestall this disaster, widespread education of the voting public is necessary. The first step in this process is our own self-education. Perhaps we never have stopped to think that we may be in need of that, that some of the ideas we have held since our youth may be in need of revision.

We should examine our beliefs with all the critical capacity at our command. We should study and ponder with open minds proposals to which we have an instinctive aversion. Doctor Thomas Carter once wrote that the trouble with radicals is that they read only radical literature, and the trouble with conservatives is that they read nothing at all. We must erase this stigma from our record and approach these new problems from all directions, furnishing ourselves thereby with opinions perhaps somewhat changed but more solidly founded than before, for we do have new problems and they may require from us new attitudes. It is doubtless true that economic law does not change; neither does physical law. But we discover new physical laws and perhaps we may discover new economic ones. At any rate, we have behind us a marvelous record of new invention and enterprise operating under the ancient and immutable physical laws. Is it not possible that we may discover workable and useful social novelties operable under the ancient and immutable social laws?

As engineers, it is incumbent upon us to distinguish between the device that flies in the face of nature and the device that makes a new application of natural law. With our own beliefs fresh and clear and in order, we face the task of making them broadly useful. I wish to stress our responsibility as an educational force counteracting the forces of social dissolution. In our national meetings, in the meetings of our local sections, in our personal appearances before other bodies and groups, in our private conversations, in human contacts which we must learn to multiply and elaborate, in every way ingenuity can provide, with all the patience and wisdom at our command, we must speak and work for the continuance of an ordered society that moves forward to higher material possessions, more fruitful leisure, and deeper spiritual achievement.

What to Do in an Air Raid

INSTITUTION OF MUNICIPAL & COUNTY ENGINEERS

GRIM reading indeed is the address by R. Nicholas on air-raid precautions in so far as they affect the department of municipal and county engineers and cleansing superintendents, presented at the Public Health Congress, Nov. 20, 1936, and published, with extensive discussion, in the *Journal* of the Institution of Municipal and County Engineers (Great Britain). It is no tale of kissing in an arbor with which the fat boy of Dingley Dell "wants to make your flesh creep," but of stark potential terror from the skies over England in case of air raids with man's triumphs of science directed to the mass destruction of human beings and their towns.

Mr. Nicholas confines himself to a brief outline of the air-raid precaution duties which will be administered by the municipal and county engineer and cleansing superintendent, but in an organization chart he includes medical-, police-, and fire-departments' duties.

The elaborateness of detail with which preparations are being made for a course of action during and following an air raid on a town is astounding to persons to whom such attacks are academic matters. Provisions for quickly setting up first-aid stations, for decontamination service, for bombproof shelters (some of the discussers despair of their effectiveness as 12 ft of concrete seems to be the least that will offer protection in event of a direct hit), gas masks for citizenry and babies, a gas-proof room in every house, obligation of employers to provide gas shelters for their employees, materials, vehicles for transporting water, means of communication (public services of electricity, water supply, gas, and telephone are obvious targets), protective clothing for the decontamination workers, cleansing of gas-contaminated clothing, treatment of gassed persons, and training programs for workers are topics which suggest the magnitude and complexity of the problem.

Differences of opinion, some on fundamental points, are de-

veloped in the discussion. What about persons caught in the streets? How can the poor afford gas-proof rooms? Will not a short-wave radio communication system permit the raiders to locate vulnerable points? Suppose the ablebodied men trained for protective and decontamination work are called for military service? While Mr. Nicholas answered some of these questions and others, a sense of the nightmare that hangs over some civilized nations lingers after reading the address and discussion.

High-Altitude Flying Record

ENGINEERING

THE essential facts of the high-altitude flying record set by Flight-Lieutenant M. J. Adam, of the Royal Aircraft Establishment, Farnborough, on June 30, 1937, are given in a brief note in *Engineering* for July 9, 1937.

A Bristol-138 single-seater high-altitude monoplane, fitted with a special Bristol Pegasus engine attained an altitude of 53,937 ft. A special pressure suit and helmet equipped with oxygen breathing apparatus were worn by the pilot. The ascent occupied 1 hr 35 min and the total flight 2 hr 15 min. The sky was clear and there was practically no wind at the start, but a strong westerly wind was encountered in the upper atmosphere and during most of the flight the ground was completely obscured by clouds. The performance of both aircraft and engine was said to be satisfactory and no trouble was experienced with the flyer's suit. At the maximum altitude the barometric pressure was 77.8 mm of mercury and the air temperature —48.9 C (—55.75 F).

Helium for Zeppelins

DEUTSCHER AKADEMISCHER AUSTAUSCHDIENST E.V.

COMMENT on the *Hindenburg* disaster and subsequent events is to be found in the June 25, 1937, issue of *News in Brief*, reports and documents on contemporary Germany published by the Deutscher Akademischer Austauschdienst e.V., in an article "Cooperation in Air Navigation."

Relative to the lessons of the disaster it is said that after the conclusion of the investigations into the causes of the disaster experts and significant members of the American Government were agreed that the *Hindenburg* and the *Graf Zeppelin* had proved their efficiency even in the most difficult flying conditions. They were not only "good-weather" ships, but they had been unusually successful and had proved their flying capacity. The *Hindenburg* was certainly no victim to any error in construction. However, if it was an actual fact that hydrogen—in spite of all possible precautions—would explode in a series of ways which can scarcely be avoided, it had also been scientifically proved, as explained by American physicists, that even a spontaneous explosion of hydrogen escaping under pressure is possible. Thus, for the future, it could be said that air navigation must apply nonexplosive, incombustible gas.

The amount of helium available in the United States is discussed in the review and Dr. Eckener's comments made before government groups in the United States are briefly reported, as is also his report on the disaster. In connection with future plans the article states that since his return from America Dr. Eckener, chairman of the Zeppelin Airship Construction Co., has had numerous conferences with his collaborators. Krupps, of Essen, is said to be supplying the necessary steel containers for the transport of helium from the United States to Germany, and to finance the helium purchases a German-American company is said to have been formed.

The rearrangement of gas-bags and other alterations in the new airship *LZ 130* for changing over from hydrogen to helium are reported to be so far advanced that this airship will be able to start on its maiden journey about Christmas time.

As helium has a smaller lifting capacity than hydrogen, this new vessel will accommodate only 40 passengers instead of 70 as originally planned.

Relative to the new zeppelin, now under construction it is said that the *LZ 130* has been constructed in complete accordance with the model of the *Hindenburg*. At the time of the inspection the skeleton was completely finished and part of it was even covered. The stern was still under scaffolding. The main work during the next few months will be devoted to the erection of the pilot and motor gondolas, the fitting out of the passengers' and crew's quarters, the installation of motors, lighting arrangements, water, and air and fuel conduits. The dockyard authorities estimate that they will be able to complete the airship by autumn of 1937.

Just as in the other zeppelin airships of recent years the *LZ 130* will also convey passengers, as well as mail and freight, over long distances, especially over transatlantic routes. Its highest speed has been reckoned at 135 km per hr. It has a gas volume of 190,000 cu m, i.e., sufficient also for the application of helium as a lifting gas.

The body of the ship 248 m by 41 m is streamlined in form, and is somewhat more slender than that of the *Graf Zeppelin*. The body is constructed according to the old method with alternating covered main rings and uncovered auxiliary rings and longitudinal girders. A specially sound material, which was made for the *Graf Zeppelin*—alloyed aluminum—has been used for the construction of the skeleton; a featherweight, durable, and pliable substance. The outer covering of the airship is of a cotton material, made weatherproof and firm by a specially prepared process.

The engines have a maximum capacity of 4200 hp. Diesel engines from the Daimler-Benz firm are used. The method of building the motors in gondolas outside the actual body of the ship has proved to be satisfactory and will be applied in the construction of the *LZ 130*. Connecting corridors and ladders will make these gondolas accessible, and they will be constantly manned during the journey, since a perfect system of supervision is necessary for the smooth working of this engine. The motor gondolas also afford sufficient space for the carrying out of repairs. The airship carries a fuel supply amounting to 60,000 kilos of heavy oil. The oil containers are attached to the stern of the ship from which the oil is conducted to the engines.

Transient Phenomena

JOURNAL OF THE FRANKLIN INSTITUTE

SUDDEN changes of pressure and velocity in a liquid column often exert an important influence on the functions of engineering devices and have to be taken into consideration in design. Examples of such phenomena are water hammer in hydraulic conduits and the injection process in Diesel engines. To this group of phenomena belong also, in a broader sense, surges in mechanical springs and columns of gas, and even the transient phenomena in electrical circuits.

In the April, May, and June, 1937, issues of the *Journal of the Franklin Institute*, Kalman J. De Juhasz, member, A.S.M.E.,

presents a graphical analysis of transient phenomena in linear flow in a paper bearing that title. To this rather extensive paper a bibliography on the subject is appended.

Professor De Juhasz shows that four variables enter into the consideration of any comprehensive treatment of transient phenomena in fluid flow. These are: The instant of time t, the position of the liquid column x; the velocity of flow v; and the pressure p. He states the problem as follows:

Knowing the dimensions of the hydraulic system, its individual condition of equilibrium, and the characteristics of the disturbance as a function of the time t, determine the response of the system as expressed by the values of the velocity v and the pressure p at any point x of the system as a function of time t.

The human mind, he observes, is incapable of visualizing a

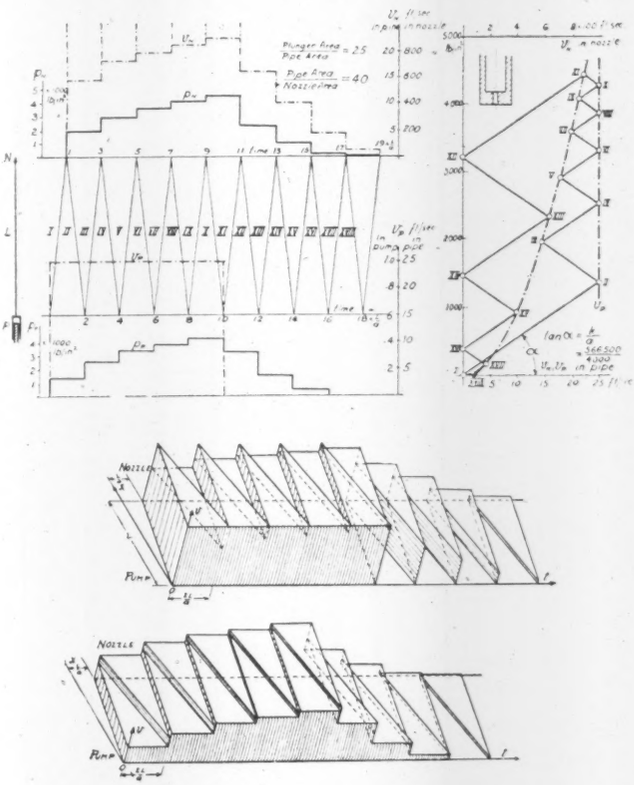


FIG. 1 GRAPHICAL ANALYSIS OF TRANSIENT PHENOMENA

four-variable function and previous analyses of the phenomena, which have mainly involved equations and computations, have not furnished a mental picture of the interrelated changes. In his analysis an attempt is made to correct this deficiency.

The concept in Professor De Juhasz' treatment lies in considering the phenomena in terms of a pair of three-dimensional functions, namely

$$v = f_1(t, x) \text{ and } p = f_2(t, x)$$

It is possible to represent each of these functions as an easily visualized stereogram in which the velocity v and pressure p, respectively, are the vertical ordinates erected on a base whose horizontal dimensions are time t and position x. The problem then resolves itself into finding the data from which this pair of stereograms can be constructed.

Two interrelationships are introduced by means of which the procedure is possible:

(1) The interrelationship between time and position of the disturbance front which can be represented in the t-x diagram by straight lines having a slope

$$\Delta x/\Delta t = \tan(\pm \phi) = \pm a$$

in which a is the velocity of propagation in the liquid.

(2) The interrelationship between a velocity change and the corresponding pressure change which can be represented on the v-p diagram by straight lines having a constant slope

$$\Delta p/\Delta v = \tan(\pm \alpha) = k/a$$

in which k is the elastic constant of the liquid.

According to the conception upon which the analysis is based, every hydraulic system can be visualized as consisting of two or more of the following elements: The pump, the pipe, the nozzle, the storer (i.e., reservoir or accumulator), and the swinger (i.e., the mechanism by which oscillation is set up, such as a free plunger).

These elements can be represented in the t-x or v-p diagram, or in both, by characteristic lines. Bringing these lines into intersection with one another in a suitable manner, the pressure and velocity values pertaining to a given position x in the system and a given instant of time t can be determined.

Several examples, fully worked out, such as the case representing the injection by a pump through a pipe and an open nozzle, are given in the paper. Fig. 1 shows the stereograms of velocity and pressure obtained for this case by means of graphical analysis.

Professor De Juhasz' graphical analysis is in full accord with the mathematical analysis as is demonstrated in the paper by an example worked out for both methods. This case deals with the motion of an inert mass, attached to a plunger, entering into a reservoir filled with liquid. The ensuing motion of the mass is a harmonic vibration, the data of which are correctly obtained by means of the graphical analysis.

Full derivation of the formulas and procedures used in the graphical analysis is included in the paper. The bibliography, which is quite extensive, relates to water hammer, fuel injection, and surges in gas columns and mechanical springs.

Flash-Curing of Rubber

INDUSTRIAL BULLETIN OF ARTHUR D. LITTLE, INC.

CONTRARY to tradition which sets the maximum temperature for the curing of rubber at 170 C in some and 163 C in other plants, the Western Electric Company and the Bell Telephone Laboratories in cooperation, according to the July issue of the *Industrial Bulletin* of Arthur D. Little, Inc., have developed a process for vulcanizing the rubber cover of an insulated wire at temperatures above 170 C and up to 198 C. At the latter temperature a cure is effected in less than twenty seconds as against twenty minutes at 142 C. To accomplish this a high degree of organic acceleration is employed. The advantages claimed are not restricted to speed. In addition, the distortions during processing of the weak, plastic mass, characteristic of unvulcanized rubber compounds, are avoided, a more uniform mechanical and electrical product is obtained, and the desired chemical properties are retained.

The process is not applicable to all rubber vulcanization, but it may be extended to some classes of rubber products. Among the principles involved are the absence of compounding ingredients appreciably volatile at the temperatures employed, sufficient heat conductivity of the mixture obtained by compounding or by limited thickness of the rubber, a mechanically

dense nonporous rubber compound, and adaptability to a continuous curing process.

From these considerations the process appears to be applicable to the manufacture of tubing, some grade of packing, thin sponge-rubber sheets, rubberized fabrics, vulcanized sheet rubber, and other similar uses. Employing these principles, the vulcanization of latex could be carried out as a continuous process by modifying details to adapt the process for the handling of liquids at temperatures below those required for dry compounds, but above those employed in the batch method.

Water-Jet Pumps

UNIVERSITY OF CALIFORNIA PUBLICATIONS IN ENGINEERING

THE water-jet pump was first used by James Thomson about 1852 and the theory of pumping by jet action was developed by Rankine in 1870. The low efficiency of this pump has limited the field of application to conditions in which the absence of valves or working parts and the small size of the unit are sufficient to offset its greater power requirements. This unfavorable circumstance has caused the water-jet pump to receive meager attention, and for this reason James E. Gosline and Morrough P. O'Brien undertook investigations of it at the hydraulic laboratory of the University of California. These investigations are reported in a paper to be found in the University of California Publications in Engineering, Vol. 3, No. 3, a reprint of which has recently been received.

The basic principle of the jet pump is the transfer of momentum from one stream of fluid to another, say the authors. The general class includes injectors and steam-jet air pumps as well as the water-jet pumps, but the latter possess the advantage of involving neither compressibility nor heat transfer.

In a foreword to the reprint B. M. Woods says that application of the jet pump to fluids other than water merits consideration. For oil-well pumping from shallow wells, after gas-lift production becomes uneconomical, the authors indicated in a paper before the American Petroleum Institute in 1933 the conditions under which the experimental results for water can be used. Likewise, he points out, a jet pump for mine ventilation is being developed.

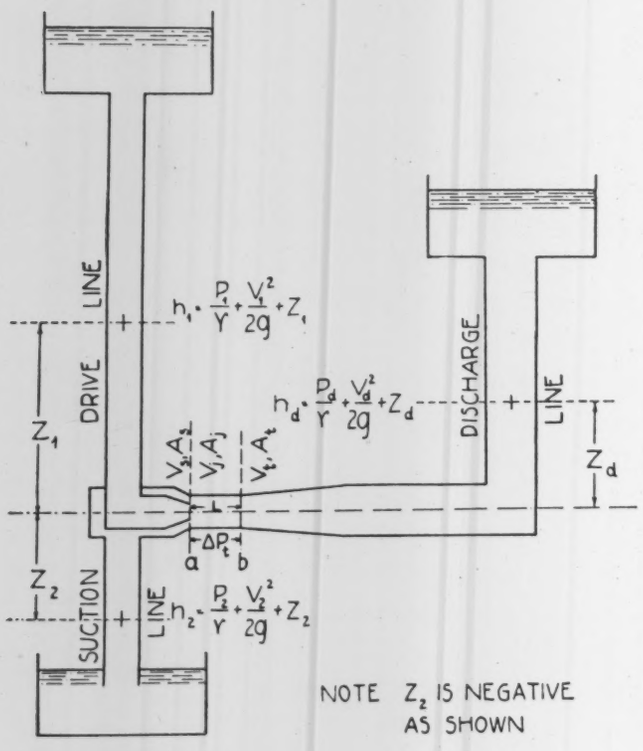


FIG. 2 SCHEMATIC ARRANGEMENT OF WATER-JET PUMP

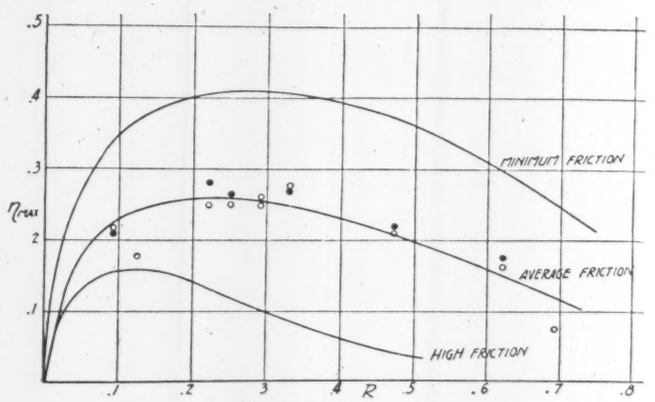


FIG. 3 COMPUTED AND EXPERIMENTAL VALUES OF MAXIMUM EFFICIENCY

(Solid lines represent efficiency computed by equations developed by the authors; circles represent experimental results.)

In the paper by the authors the theoretical equations are presented in dimensionless form. The treatment of the theoretical study involves the computation of friction losses in three pipe lines (the drive line, the suction line, and the discharge line) and the impact loss and pressure change in the mixing chamber. Fig. 2 shows the jet pump in schematic outline.

Efficiency curves are shown in Fig. 3, for various ratios R of nozzle to throat area. The authors comment that although the curve of maximum efficiency as a function of area ratio is fairly flat in the region giving the maximum possible efficiency, the choice of the area ratio, and hence of the characteristic curve, is limited to a region 0.25 ± 0.10 for the design tested, if a reasonable efficiency is to be attained. For maximum efficiency the head and quantity ratios are fixed by the area ratio and this seriously limits the operating conditions. For example, a small high-pressure pump supplying a small nozzle cannot be used to pump a relatively large quantity through a small head if the efficiency is to approach the maximum value. The curves of Fig. 3 indicate that the region of high efficiency becomes wider as the friction is decreased, but the extent to which this improvement can be effected is said to be still problematical.

E.P. Lubricant Tester

ENGINEERING

A FOUR-BALL top for testing the boundary lubricating properties of extreme-pressure lubricants under high mean pressures (10,000 kg per sq cm) is described by G. D. Boerlage and H. Blok in the July 2, 1937, issue of *Engineering*. While the four-ball principle has been used in another instrument which works with sliding speeds of 50 cm per sec and more, the four-ball top works at very low sliding speeds, 0.1 to 1 cm per sec. It is also arranged so that the oil cup can be heated electrically up to 300 C.

By means of the instrument, which, it is said, has been de-

veloped at the Delft engine-testing laboratory of the Royal Dutch Shell Company, Holland, the influence of the temperature on the friction coefficient has been tested and plotted in temperature-friction-coefficient curves. The influence of combinations of different metals on boundary lubricating properties has also been studied.

The arrangement of the four-ball is shown in Fig. 4 with enlarged details of the balls. The lower three balls *b* of the set of four are fitted tightly in the oil pot *c*, which is provided with an electric heater *d*. The upper ball *a* is fixed in a weighted arm *e*. This arm can be rotated, the ball *a* fixed to it making "point" contact with the upper surfaces of the three other balls. A definite initial angular speed can be given to the arm by means of a drop-weight and pawl arrangement. Care is taken that the arm is properly balanced and that it is propelled in the horizontal plane through its center of gravity so that it will not oscillate. The load normally applied is 5.5 kg.

After the arm has been set in motion it is braked by the friction between the balls and will come to rest again after a definite time which can be measured. As the weight and moment of inertia of the arm are known, and provided that the friction

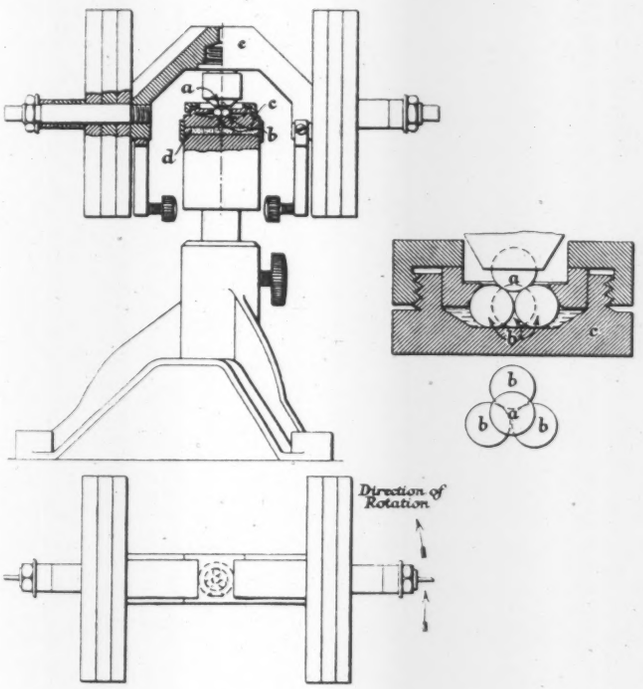


FIG. 4 VIEWS OF FOUR-BALL TOP WITH ENLARGED DETAILS OF BALL ARRANGEMENT

between the balls is constant throughout the test, the friction between the balls and also the coefficient of friction f can be calculated from the formula $f = C\frac{n}{t^2}$.

That the friction is constant providing no seizure occurs has been proved. In the formula n is the number of revolutions and t the running time, while C is a constant dependent on the weight and moment of inertia of the arm and on the size of the balls. Normally n varies from about 2 to 10 and t from about 5 to 30 sec.

The temperature of the oil bath can be regulated by means of the electric heater up to 300 C and is measured close to the balls by means of a mercury thermometer. Notwithstanding the high mean pressure, however, the temperature rise due to friction is negligible on account of the low rubbing velocity.

After the oil to be tested has been introduced into the oil pot, a measurement is first carried out at room temperature, after which the temperature of the oil is raised and the friction measured step by step without adding fresh lubricant. When seizure does not occur during a run, no wear, or hardly any, is perceptible at the points of contact. Nevertheless, after each test the balls are loosened and rotated before being fitted tightly again for the next measurement, in order to avoid running on points of contact already used, and so to make sure that the

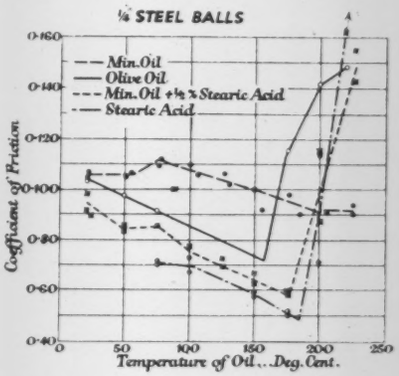


FIG. 5 TEMPERATURE-FRICTION-COEFFICIENT CURVES OF FOUR OILS

conditions of each test are absolutely identical. In this way a temperature curve of the coefficient of friction of the lubricant tested is obtained. If seizure occurs, the wear is immediately visible on the balls. A set of such curves for four different oils is given in Fig. 5, showing the breakdown points.

Lubricating High-Speed Diesels

JOURNAL OF THE INSTITUTE OF FUEL

SOME of the problems involved in the lubrication of high-speed Diesel engines are discussed by H. Ricardo in a paper entitled "Engine Testing" to be found in the April, 1937, issue of the *Journal of the Institute of Fuel*. Concerning these lubrication problems Mr. Ricardo says:

The lubrication of the really high-speed Diesel engine is a problem that vexes the designer. In the gasoline engine it is difficult enough in all conscience, but in the Diesel it is much worse, for we have higher gas pressures, heavier moving parts, and higher dynamic loadings to contend with. The problem is not so much that of conveying an adequate supply to all the rubbing surfaces, for this is merely elementary plumbing, but rather of achieving adequate lubrication without flooding the cylinder walls.

In any high-duty engine the lubricating oil must serve the dual purpose of lubricating and cooling the bearings. It is over the second of these two duties that the difficulties arise. Where the load factor on a bearing is relatively small and such that the heat generated by friction can pass away by the normal conductivity of the metal, splash or measured-feed lubrication will suffice, and is much to be preferred on many grounds. But when, as in high-speed internal-combustion engines, the load and rubbing velocity are so high that the heat generated by friction is beyond the capacity of the moving parts to dispose of by conduction, we are compelled to use forced lubrication and to circulate large quantities of oil at high velocity through the bearings merely in order to carry away heat.

In the high-speed Diesel engine, owing directly to the higher

and longer sustained gas pressures and indirectly to the heavier moving parts competent to endure these higher pressures, the loading on the main and crankpin bearings is considerably greater than in a gasoline engine of equal dimensions and speed—more heat is therefore generated at the bearings, and more oil is required to take it safely away. To this there would be no great objection were it not for the fact that it means that more oil is thrown on to the cylinder walls from the crankpin bearings. Although much has been done in the way of improving piston design and oil-scraper rings with the object of preventing the passage of oil past the piston, yet even in the best of modern high-speed engines the quantity of oil passing the piston is excessive, and, moreover, the best of scraper rings fails altogether to cope with the problem when the supply of oil to the cylinder walls exceeds a certain amount; again, a very little wear either of the liner bore or of the rings will lower their oil-resisting efficiency enormously.

The bearing in a high-speed engine which requires the most copious supply of all is the connecting-rod big-end bearing, for not only is it very heavily loaded, but since heat from the piston is pouring down the shank of the connecting rod, that outlet for the disposal of heat is closed, and it has to rely solely on conductivity along the crankshaft and on oil cooling. As the speed increases, the load factor on the connecting-rod big-end bearing increases very nearly as the cube, and the heat generated only slightly less so. Adequately to cool this bearing in the normal manner we must circulate through it a very large quantity of oil, and the quantity should increase rapidly with increase in speed. Fortunately this takes place automatically, even with a constant oil pressure, for the higher the speed the higher the rate of leakage through the bearing and the higher also the centrifugal pressure at the crankpin.

To some small extent we can control the quantity of oil thrown from the connecting-rod bearing onto the cylinder walls by means of baffles; but when, as in road-vehicle engines, the connecting rod is short and the engine very compact, our scope in this direction is very limited, for though it may be possible to interpose baffles in the direct path of the oil from the crankpin, yet the air displacement on the underside of the pistons will divert the oil from the direct path, and more often than not we find that the addition of baffles of almost any form has increased rather than reduced the consumption at high speed. In any case, however, baffles are objectionable, and even dangerous, for they tend to starve the pistons at low speeds or when the oil is cold, besides being generally ineffective at high speeds.

With oil supplied to the crankshaft at a constant pressure we find in practice that the oil passage past the pistons of either a Diesel or a gasoline engine increases very nearly as the cube of the speed, owing in part to the greatly increased quantity thrown onto the cylinder walls and in part to the reduced efficiency of scraper rings, etc., at the higher speeds. The high consumption of oil is objectionable on the grounds both of cost and of carbonization of the rings. Furthermore, the passage of oil past the piston is much more objectionable in a Diesel than in a gasoline engine on the grounds of smoke and smell. In the latter, owing to the high mean temperature of the cycle and the high temperature of the exhaust, most of the oil passing the piston is burnt efficiently as fuel; but in the Diesel engine, when running light, the mean temperature is so low that much of the oil passes as a liquid into the exhaust pipe, where it accumulates until the engine is loaded, when it is boiled off in a dense cloud of smoke.

Our experiments have shown, and others have confirmed, that at 2000 rpm the quantity of oil required adequately to lubricate the pistons is less than one tenth of the minimum normal consumption at this speed. It would seem, therefore, that the time has arrived when we must separate the functions of cooling and lubricating. This can be done by employing the oil circulation to cool internally the crankpins. In one construction which we are using, the whole of the delivery from the oil pump passes from end to end through the hollow crank shaft. For the better cooling of the crankpins, and also in order to avoid the deposition of sludge, the hollow crankpin is filled with an aluminum plug, leaving only a spiral passage through which the oil passes at high velocity. The quantity of oil passing through the crankshaft is about three times the normal supply, and is quite adequate to carry away all the heat generated at the crankshaft journal and crankpin bearings.

For the lubrication of the connecting-rod big-end bearing a small hole is drilled through the underside of the crankpin in a position where the centrifugal force acting on the oil is at minimum, while that acting on the connecting-rod big end tends to keep the oil passage closed during 90 per cent of the cycle when the engine is running at high speeds. With such an arrangement the oil consumption can readily be controlled; it is reduced to a very low figure indeed, and is not nearly so dependent on the use and correct operation of oil-scraper rings. Such an engine can be run idle for an hour or more and then opened up suddenly to full load without the least trace of blue smoke in the exhaust.

Some difficulty was at first experienced due to the presence of air in the oil; this had the effect of breaking the continuity of the oil column through the crankwebs, with the result that a very high oil pressure became necessary to overcome the centrifugal force at high speeds. The difficulty was successfully overcome by allowing the air from the center of the hollow shaft to bleed out into the journal bearings; thus provided, the system operates with quite a reasonably low oil pressure—namely, from 1 to 4 atmospheres—over the speed range of from 250 to 3000 rpm.

Impact-Extruded Zinc Parts

PRODUCT ENGINEERING

A METHOD of extruding zinc parts by impact is described by Herbert Chase in the June, 1937, issue of *Product Engineering*. It is said that the process makes possible economic quantity production of designs having a wide range of shapes and sizes and marked variations in section thickness, with integral projecting lugs, bosses, and tubular extensions.

Impact extrusion, writes Mr. Chase, involves the use of a punch and die in a heavy press of special design. Under the impact of the punch, solid metal in the shape of a circular slug is caused to flow and assume the form desired.

The process of extrusion, which in some cases closely resembles forging, is done with a single blow, workhardens the metal, and renders it stiffer for a given section thickness than the metal in the slug. The diameter and thickness of the slug used vary with the part to be produced and the slug has the same volume except for allowance for trim. Slugs have to be slightly smaller in diameter than the die opening which controls the diameter of the piece, and the thickness of a slug never exceeds, and is usually much less than, its diameter. Conversion of the slug to the form of the part produced results from the impact of the punch, which is smaller in diameter than the die opening by an amount equal to twice the tubular wall thickness of the part. The impact pressure of the punch upon the ductile metal causes the slug to expand, fill the die, and then flow upward around the punch through the

annular space that exists between the punch and the die cavity.

Metal extruded upward through the annulus forms the side wall of tubular parts, and that remaining between the die and the punch, when the latter is at the bottom of its stroke, forms the bottom of the part together with any projections on that portion of the piece. When the punch is withdrawn, the extruded part is stripped from it. Since the part is formed in a single stroke, the time required is short and production is correspondingly rapid.

If a hole is required in the center of the bottom, a slug with a central hole is sometimes used. The hole can also be punched in a separate operation and it can then be located in any part of the bottom, or more than one hole can be punched if desired.

The punch and die may have flat bottoms, but slightly conical bottoms are desirable since they have a tendency to hold the punch concentric with the die and thus make for uniformity in wall thickness. Wall thicknesses are readily held within plus or minus 0.003 in. of nominal thickness, sometimes closer, and bottom thickness within plus or minus 0.007 in. for commercial tolerance.

Outside diameters of extruded zinc products thus far produced have ranged from 0.437 to 2.125 in. Within this range a number of diameters have been standardized and, when adhered to by designers, permit new parts to be made with minimum tooling costs, since existing dies may be employed for the extrusion as well as for punching the slug. Wall thicknesses can be varied within certain limits, the lower limit being about 0.020 in. for the largest size and about 0.014 in. for the smaller sizes, although some parts with a minimum wall thickness of 0.012 in. have been made. Total height of side walls ranges from $2^1/_2$ in. maximum for the smallest, up to 7 or 8 in. for the largest diameter. Maximum wall thickness depends on slug volume, thickness of bottom, and total height required.

Spectroscopy in Industry

JOURNAL OF SCIENTIFIC INSTRUMENTS

ALTHOUGH spectroscopic methods of analysis are now finding useful applications in several industrial establishments, according to A. Fowler in his presidential address at the Second Industrial Physics Conference, Birmingham, England, of the Institute of Physics, reported in the May, 1937, issue of the *Journal of Scientific Instruments*, there can be little doubt that if the simplifications and facilities available were more generally known, these methods would be more widely adopted.

It is recalled by the author of the address that what has been claimed as the first use of the spectroscope for an industrial purpose was to control the air blast in a Bessemer converter. This use was discovered by Roscoe in 1863, who found that a striking change in the spectrum occurred at the moment decarbonization of the charge was complete.

Qualitative spectrum analysis, says the author, is comparatively simple. In routine ways, by the use of an arc or spark, the spectroscope may be used for the detection of any of the metallic elements and for the nonmetals boron, arsenic, phosphorus, carbon, antimony, silicon, and tellurium, but special technique is necessary for the remaining elements. The fundamental operation is to determine the wave lengths of the lines in the test sample by interpolation with reference to a comparison spectrum containing lines whose wave lengths are known, and then to find their origins from tables or maps. In visual observations matters are greatly simplified by the use of a "wave-length spectroscope," by which wave lengths can be read off with sufficient accuracy for most purposes of spectrum analysis on the scale of the instrument itself. Another simplified spectroscope for industrial use mentioned by the author is the Steeloscope (see MECHANICAL ENGINEERING, July, 1937, page 527) for the rapid testing of steels. Although much valuable work can be done by visual observations, a much wider field can be covered by photographic methods.

Much attention has been given in recent years to the possibility of making the spectrum analysis quantitative, says the author. The idea underlying most methods attempted is that as the percentage of an element in a mixture or alloy is reduced, there will be an accompanying decrease in the intensities of its spectrum lines, and that a correlation between the percentages and intensities may be found by experiment. Unfortunately, he says, there is as yet no general theoretical principle applicable to quantitative analysis and each problem has to be worked out individually.

The most direct method of quantitative analysis, he points out, is to confront the spectrum of the test sample with a series of prepared standards suitable for a particular problem, all of them being taken under precisely the same conditions and on the same photographic plate. Then by visual inspection it can be ascertained that the percentage of the minor constituent is equal to that in one of the standards.

Several industrial applications are mentioned by the author, such as control of lead sheathing for aerial cables, routine analysis of brass and lead alloys, determination of the quality of scrap metal, and the sorting out of wrong materials from batches of bars.

Polarized Light

TRANSACTIONS OF THE ILLUMINATING ENGINEERING SOCIETY

A SCHEME for eliminating glare from headlights of motor vehicles and at the same time providing ample illumination of the roadway by means of polarized light is described in a paper by L. W. Chubb in the Transactions of the Illuminating Engineering Society for May, 1937.

In explaining the nature and properties of polarized light Mr. Chubb says that light is an electromagnetic radiation having the properties of a wave motion in which the amplitude of oscillation is at right angles to the direction of propagation. In natural light, the vibrations are random or, we may say, at all angles. In polarized light the vibrations have some regular motion in parallel planes, or in quadrature planes. There are several kinds of polarized light—plane polarized light, in which the vibrations are in parallel planes; circularly polarized light, in which the vibrations are in quadrature planes of equal amplitude and in quadrature time phase; and elliptically polarized light, in which vibrations of the same frequency in two different planes have different amplitudes or phase, so that they result in an elliptical motion.

To illustrate these effects, imagine a rope fastened to the wall and stretched out horizontally and loosely. Now suppose the free end is shaken sideways, up and down, and at all possible angles in an irregular manner. Waves will be propagated along the rope which will vibrate each point along its length in a random way. This may be likened to the propagation of a ray of natural light with its random vibrations.

Now if we shake the free end up and down, polarized waves will be propagated along the rope and the waves will be in a vertical plane. If we shake the free end horizontally, polarized waves vibrating in the horizontal plane will be produced.

Let us now assume the rope to pass between the pickets of a

fence located midway between the ends of the rope. The vertical slot between the pickets will allow only a vertical vibration of the rope. A random shaking of the free end will make random waves travel as far as the fence and only the vertical components of these waves will pass beyond the fence as vertically polarized waves. If we shake the rope up and down, the vertically polarized waves will pass freely through the fence and beyond. If we shake the rope horizontally, the horizontally polarized waves will stop at the fence because there are no vertical components to be transmitted.

Again, if the free end is moved in a circle, we propagate circularly polarized waves as far as the fence and only the vertically plane-polarized waves go beyond.

In our illustration, the fence represents a polarizing device such as used to plane polarize light waves. It changes random, circular, or oblique vibrations to polarized vibrations in a vertical plane. It allows vertically polarized vibrations to pass freely and it stops horizontally polarized vibrations.

In working with light we have one polarizer to produce polarized light and a second one, usually called the analyzer, to select or reject the polarized light.

For vehicle lighting, the first polarizer is used to polarize the light projected from the headlamp, and the second or analyzer may take the form of a viewing screen, windshield, goggles, or eye-glasses before the eyes.

When two polarizers are arranged with their planes of polarization parallel, they are said to be "optically coincident" and the second transmits the light which has passed through the first. When two polarizers are arranged with their planes of polarization at right angles, they are said to be "optically crossed," and the second stops the polarized light passed by the first.

Mr. Chubb shows that light may be polarized by reflection, refraction, and by absorption, and that for vehicle lighting with polarized light three systems are available: (1) All headlights are polarized in the vertical plane and are seen by the driver of an approaching car through an analyzing screen polarized in a horizontal plane, or vice versa; (2) vertical polarization is used in lamps and viewing screens in cars traveling in one direction, and horizontal polarization in both places in cars moving in the opposite direction; (3) planes of polarization of both headlights and screens of the same car are arranged at 45 deg to the horizontal. This system, says Mr. Chubb, is preferred. Since the viewing screens and headlight coincide optically on each car, the driver will obtain a maximum of reflected light from objects illuminated by his lamps and by lamps on cars traveling in the same direction. For cars traveling in the opposite direction the planes of polarization will be perpendicular to each other and the rays from an opposing lamp will be stopped by the viewing screen or analyzer, thus eliminating all blinding glare.

Mr. Chubb says that after experimentation he found that polarizers of the required aperture could be made by orienting the small and easily obtainable crystals of herapathite or tourmaline in a matrix or on a transparent support having the desired area. He discusses briefly the design of headlights and viewing devices, and the relative advantages and disadvantages of the proposed lighting system. An appendix develops the formulas necessary for a quantitative treatment of the factors brought into the lighting problem because of the use of polarized light.

[In a dispatch to the *New York Times*, dated Washington, July 24, 1937, it is stated that after 17 years in the Patent Office involving six interferences with other inventors, the basic patent (No. 2,087,795) on the use of polarized light for eliminating automobile-headlight glare has been granted to Lewis W. Chubb, director of research of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. The dispatch goes on to say that in 1919 Mr. Chubb's wife was killed in an accident when the driver of the car in which she was riding was blinded by the headlights of another. Mr. Chubb, therefore, sought a solution of the glare problem, and in 1920 hit upon polarized light and applied for a patent.]

Phototube Temperature Control

ELECTRONICS

SEVERAL typical adaptations of phototube temperature control are mentioned by R. A. Powers in the April, 1937, issue of *Electronics*. While most of them are drawn from the field of automobile manufacture, they are suggestive of uses to which this control mechanism may be applied in other industries.

Mr. Powers' first example has to do with a welding operation on a valve stem in which welding current is turned off by the photoelectric control unit when a temperature of 1800 F is reached. As the welded valves drop from the machine into a quenching tank it is important that the heating and quenching of the stem do not harden it in the region of the slot or groove for the device which holds the valve spring. The temperature-control device cuts off the current before danger of this condition exists.

Other examples cited by Mr. Powers are: (1) Controlling resistance heaters used for shrinking the metal shell on the ceramic insulator of spark plugs; (2) controlling resistance heater for annealing the central section of automobile front-axle king pins; (3) controlling an electric silver-soldering operation in the assembly of the stainless-steel spokes to the metal rim of new-type steering wheels; (4) indicating the pouring temperature of an iron-foundry cupola; (5) automatic indexing of copper billets from which soft-copper tubing is extruded; and (6) continuously indicating temperature of sheets in a sheet mill.

Mr. Powers says that there are now available phototube temperature-control units with an accuracy of plus or minus 5 F throughout the entire spectrum from 985 to 3300 F, with relay contacts capable of controlling a 500-watt noninductive load. A special recording milliammeter may be used in the plate circuit of the final stage of amplification so that an actual record of the temperature control may be obtained.

Platinum Thermometers

PHILOSOPHICAL MAGAZINE

REPORTS on the construction and sensitivity of a number of platinum thermometers are to be found in a paper by J. J. Manley, *Philosophical Magazine*, seventh series, No. 156, supplementary, April, 1937. In experimenting with the thermometers the chief object was the discovery of an instrument having a minimum heat capacity and, for the limited volume of its bulb, a maximum resistance, and, moreover, capable of instantaneously responding to small variations in temperature.

Fig. 6 shows the various forms of platinum thermometers constructed and tested. At the left is the standard of reference used, a platinum-on-mica thermometer enclosed in a glass tube and made by the Cambridge Instrument Co. The reduced replica of this thermometer is form *A*, in which the thickness

of the intersecting mica plates was reduced to 0.1 mm, the irregular edges being sufficient to hold the finely attenuated resistance wire in place.

In form *B* the wire is held on two ivory disks *i*, centrally supported by one of the silver-wire leads and held apart by capillary glass tube *z*. Through the disks small holes have been drilled so that the wire is passed from disk to disk. The ends of the wire are fused to the leads at *p* and *q*.

The core of form *C* is a thin-walled glass tube on which the wire was first wound spiralwise and then fused to it. After the ends of the coil had been attached to their leads the core was introduced into a protecting tube having a very thin wall and fused to it, permanently embedding the resistance wire. Variations of this form involved a thermometer of smaller dimensions with smaller wire; one made with a core of a slender rod of

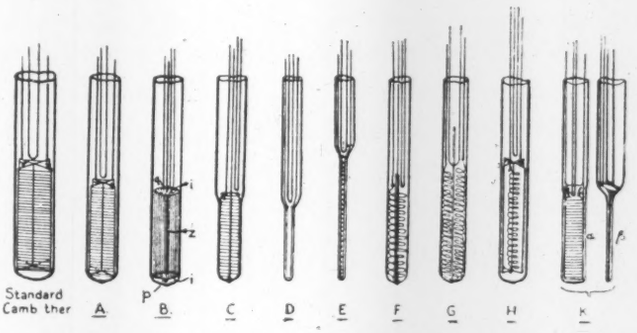


FIG. 6 FORMS OF SHORT-PERIOD PLATINUM THERMOMETERS

glass-blower's blue enamel, to which the spiral resistance wire was fused and then coated with a thin layer of the enamel; and a purchased platinum-in-silica thermometer.

Forms *D* and *E* consist of single loops of platinum wire within capillary bulbs; in *E* the loops are separated by a mica strip.

Forms *F*, *G*, and *H* consist, respectively, of 1, 2, and 4 coreless and sufficiently taut spirals of wire. In *G* the coils are separated by a mica strip, and in *H* by two thin intersecting mica plates.

Form *K* is a flat spiral on a thin mica plate.

Tests of the thermometers are described and a table of results is given, which shows that air temperatures were most quickly acquired by the single-loop thermometers (forms *D* and *E*) and the spiral on the mica plate (form *K*); water temperatures were most quickly acquired by the wire embedded in fused silica (form *C*) and the single loops (forms *D* and *E*).

Steam Locomotives

ASSOCIATION OF AMERICAN RAILWAYS

DEVELOPMENTS in steam locomotives and in railroad research have been making notable progress recently, although popular preoccupation with newer forms of motive power and trains has had a tendency to obscure them. Thus it would be a mistake to fail to realize that the steam locomotive is still the background of railroad transportation in this country, as pointed out by W. H. Winterrowd, member, A.S.M.E., in a paper entitled "Research and Steam Locomotive Development" read before the Mechanical Division at the recent annual meeting of the Association of American Railroads.

Mr. Winterrowd presents tables for freight and passenger locomotives covering a period of approximately 40 years in which steam-locomotive developments in increased weight and power are set forth. The freight-locomotive tabulation shows that in 29 years maximum cylinder horsepower per driving axle has increased from 260 to 1171, or 350 per cent, while the horsepower per ton of weight on driving wheels has increased from 12 to 31.4, or 162 per cent. In 42 years, according to the table, maximum cylinder horsepower per driving axle of passenger locomotives has increased from 261 to 1600, or 500 per cent, and horsepower per ton of weight on driving wheels from 16.8 to 45.7, or 146 per cent.

In regard to future trends in steam-locomotive developments Mr. Winterrowd makes some observations on steam temperature, boiler pressure, boiler design and fuel, steam space, air preheating, economizers, condensing, the variable exhaust nozzle, improved cylinder performance, driving-axle loads, materials, fabrication and wear, driving-wheel diameters, and locomotive tenders. At present the practical upper limit of steam temperature for the conventional type of reciprocating steam engine has been closely approached. With the present type of stay-bolted boiler a pressure of 300 to 325 lb per sq in. can be considered the present maximum upper range. Steam boilers that depart radically from conventional types, such as the forced-circulation types, are being built, and their practical applicability to the steam locomotive will be a matter of great interest to railroads and locomotive designers. Their successful development may greatly affect locomotive design.

The possibilities of improved performance and reduction in cost of firebox maintenance resulting from the use of preheated combustion air warrant a continuing interest in the subject. The problem of a practical economizer is a difficult but interesting one.

In the past, says Mr. Winterrowd, the problem of a practical locomotive condenser has been complicated by the large volume of steam involved. With the steady reduction in the amount of steam required to develop horsepower, the complications due to volume have been reduced. The development of a practical condenser will bring about a still greater reduction in the water rate.

The outstanding problem, with space and weight restrictions, is to get enough cooling surface to carry off heat. To provide enough condensing surface to permit exhausting steam into any considerable vacuum, such as in stationary practice, will require condensers beyond the size and weight limitations of existing locomotives. For that reason the development of a practical condenser will undoubtedly follow the lines of design that will accomplish a reduction in back pressure as far as possible, probably to atmospheric pressure. Any further gain, within practical limits, will be of value.

There are many problems to solve in the development of a practical condenser and their solution may result in modifications of boiler and locomotive design. However, the solution of the problem would bring about steam rates and thermal efficiencies beyond those possible at present. Such a goal is worth serious consideration. Furthermore, from a practical railroad operating standpoint, it would greatly increase the cruising range of the locomotive and be of great economic value on those railroads that traverse desert country and on those where the supply of water is a problem.

In the matter of improved cylinder performance the conventional long-cutoff type of valve gear with a minimum cutoff at approximately 25 per cent is discussed, and the need, in simple cylinders, of a shorter cutoff if high boiler pressures are used is brought out. Poppet valves provide the means of accomplishing this.

Experience in this country with compounding as a means of improving cylinder performance has resulted in a general feeling that it does not yield enough advantage of economy to offset its complications, especially when our comparatively low-cost fuel is considered.

LETTERS AND COMMENT

Brief Articles of Current Interest, Discussion of Papers in Previous Issues

The Steam Turbine in the United States

To the Editor:

Your request of May 10 to write a brief story about the Kerr turbine is answered with pleasure; I hope to offer something worth while reading, for the development of a new machine reveals problems not only in design but of finding something to drive and of satisfying the market.

For two years following 1902, I served as an engineer for Westinghouse, Church, Kerr & Co., who were then at their peak in power-plant and electric-railway work. Coming fresh from a dozen years of teaching engineering subjects, they set me to solving technical problems met in their work, like the best weight of flywheel for a given job or the probable trend in steam pressure and superheat. While at such work, the idea grew of building small steam turbines to drive centrifugal pumps and blowers for power plants instead of the high-speed steam engines then in use. As pumps and blowers are essentially high-speed machines, the purpose was sound, but a draftsman who helped to reduce the idea to a basis for patent application remarked, "Kerr, that looks like a crazy man's dream." Anyway, the invention thus revealed proved to be patentable.

With the prestige of a patent on steam turbines, which were felt to be the coming form of prime mover, it was not difficult to persuade some friends at Wellsville, N. Y., to risk their money in building them. So the Kerr Turbine Company was incorporated in June, 1904, under the laws of the state of New York. The charter and by-laws were carefully worked out. With due optimism, they provided for an increase in capital stock when desired; and to assure wide-awake minority stockholders of representation on the board of directors they could distribute their votes among all their candidates or give them all to one.

Although among pioneers in recent commercial development, the Kerr steam turbine was more than twenty centuries later than the first of record. About 120 B.C., Hero of Alexandria built a form of steam turbine that operated by the reaction of jets of steam blowing into the air and was put to useful work in opening temple doors. Showing the lack of mechanical progress during the Middle Ages, in 1577 A.D., a German mechanic used a Hero's turbine to do the work of a turnspit. Then in 1629 an Italian architect, Branca, designed a steam turbine in which nozzles directed jets of steam against the vanes of a wheel geared to operate a stamp mill. In spite of the fact that even James Watt took a fling at the problem, another two and a half centuries elapsed before the electric generator called for a high-speed prime mover. Parsons, De-Laval, Rateau, and Curtis offered answers, and their sufficiency depended upon the development of machine tools as well as upon a market. Thus at one time James Watt congratulated himself that one of his steam cylinders was only $\frac{1}{4}$ in. out of round.

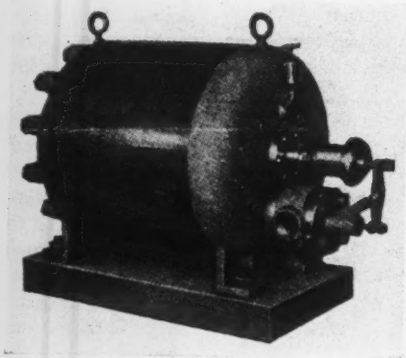


FIG. 1 THIRTY-BRAKE HORSEPOWER TURBINE FOR LOW-PRESSURE NONCONDENSING OPERATION

(Speed, 3000 rpm. Floor space 20 × 36 in. Weight, 600 lb.)

As the relatively small Kerr steam turbines were intended to run noncondensing, the Pelton type of bucket was used at first on account of its fine work in high-head water wheels. Later, the radial type was used as it handles much better the increasing volume of steam as it expands through a multistage turbine. A commercial advantage of this turbine is that it can be made largely of standard parts and then put together from stock to suit the job. Apparent disadvantages are the number of parts required and the appearance of the unit with its sheet-steel jacket. An engineering friend, to whom a photograph of one of the first turbines was shown, expressed his appreciation of the artistic merits by saying, "Kerr, that looks like a tin can." A look at the turbine shown in Fig. 1, which appeared a little more than a year from the start, will show how nearly he was right.

A steam engine is sensitive to water in the cylinder. Many a head has been blown off by a slug of water coming over with the steam. To see whether a steam turbine could take it, one was half filled with water and steam turned on. The turbine ran up to speed without noise from water hammer, and the governor took hold before steam appeared at the exhaust a few feet away. Another advantage of the steam turbine is smooth running under throttle control. The foundry foreman for the shops building the first turbines was bothered by poor blast from his cupola blower which was

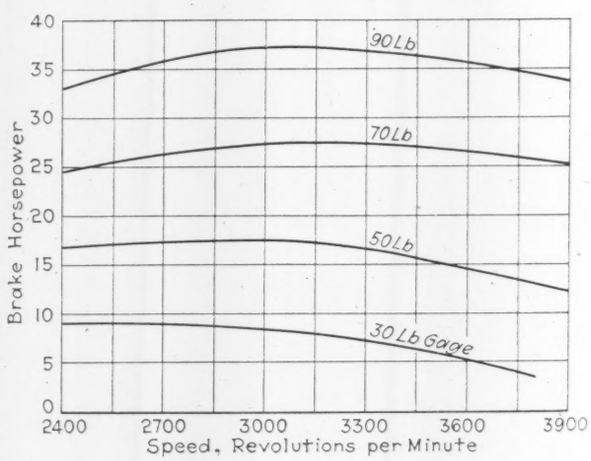


FIG. 2 SPEED-POWER CURVES OF THE TURBINE SHOWN IN FIG. 1 WHEN TESTED AT VARIOUS INITIAL PRESSURES

driven by a belt from a gas engine. A week's run showed 14 per cent loss in bad castings. Then a high-speed cupola blower was coupled on bedplate to a steam turbine without governor and installed. The turbine could not run away with the blower as long as the coupling held, and the foreman could get the blast he wanted as the heat progressed by throttling to vary the speed. Later a week's run showed the bad castings had dropped to 2 per cent, a saving of nearly one eighth of the total melt. This made a satisfied customer close home.

One of the unknown quantities about a steam turbine at the beginning was the way in which brake horsepower varied with speed and steam pressure. Tests were run on the turbine illustrated in Fig. 1, and the results are plotted in Fig. 2. It was gratifying to find that the turbine was at its best through the probable range of load at the designed speed. A turbine of this type was sold to the University of Illinois and was tested in its engineering laboratory against a high-speed steam engine of approximately the same rated horsepower. Each machine was run at rated speed under the same steam conditions, and over the entire load range. Test results were published in the *Journal of the Western Society of Engineers*. Curves of steam consumption per brake-horsepower hour at various loads were lower for the turbine, and the difference in its favor was greatest at light loads.[1] Until these results were published, the Kerr Turbine Company was not aware that such tests had been made, but naturally such information was used freely in promoting sales.

Testing all turbines for working conditions before shipment seemed so desirable from the first that an expensive test plant was provided with boilers that were capable of furnishing all the steam required by the turbines to be built at 200 lb pressure and 200 deg superheat which might be used by power plants 30 years ago. A surface condenser was installed capable of condensing all the steam produced by the boilers and maintain a vacuum up to 28 in. under control by throttling or air bleeding. The confidence quickly built up in the Kerr steam turbine by this policy was gratifying, but in one case pressure to ship excused a turbine from the routine test. Soon word came back that the turbine was not doing its work. An erecting man sent to learn that trouble reported that a set of nozzles for one stage was missing. It cost real money to remedy the fault, but it led to the obvious resolve, "Never again."

In those first years, the organization was small and for a time I was both chief engineer and business manager. A convenient way of finding the pressures for the different stages was soon developed. If n is the number of stages assumed for given steam conditions, then the nth root of final absolute pressure divided by the initial gives the ratio of expansion. That puts the problem on the slide rule. If one plots results on an entropy total heat diagram, it will be found that the available heat per stage decreases down through the turbine. But the heat efficiency of the turbine is not quite 100 per cent so that part of the available heat is passed on to lower stages. This tends to equalize the heat per stage. The magic of the diagram is revealed if one locates the initial steam condition and then follows down to final for a given water rate or assumed heat efficiency. The data permit calculation of conditions for each stage, and, as a rule, moisture will be found in the lower stages even with initial superheat. Thus on a diagram at hand the initial condition is 125 lb gage pressure, 100 deg superheat, and the final a 28 in. vacuum. The condition curve shows 1 per cent moisture at atmospheric pressure and nearly 7 per cent in vacuum. No wonder turbine blades in lower stages tend to erode.

At first, the commercial problem was to find something for the turbine to drive by direct coupling. Centrifugal pumps of that time, 30 years or more ago, were designed for high-speed engine drive, and it was comical or tragic to watch the face of a pump designer when asked to put his pump up to turbine speed. At one time, a 300-hp Kerr turbine was coupled to a condenser circulating pump at 400 rpm. A few years later a screw runner was substituted for the original which increased the speed to 1200 rpm with a reported saving of 10,000 lb of steam per hour for the unit. Since then a type of pump impeller has been developed which will give the steam turbine or the bipolar motor the speed that they require for direct coupling at most capacities and pressures. The situation was almost as bad with electric generators. But the Northern Electric Company, Madison, Wis., soon brought out a fine line of direct-current machines at fair prices, and the Burke Electric Company, Erie, Pa., did likewise for small alternators. The only machine ready and waiting was the high-speed blower used to provide air blast for cupolas in foundries and for retorts in gasworks. The usual drive was by belt from an engine. Frequent stops and starts in gasworks practice with full steam pressure under automatic or throttle control made such a drive both a nuisance and a danger, but the steam turbine with direct coupling, freedom from danger by entrained water, and almost instant starting furnished the ideal drive. So it is not surprising that among the very first units sent out were the two gas blowers shown in Fig. 3. Assembly and running tests were made at the shop, and then shipment of the equipment was made to Scotland. The Scotch reaction was a check in full payment with a request for information about adjusting the governor. That was easy as adjustment could be made with the turbine running.

Another part of the commercial problem was the sale of product. A memo at hand says that up to October 20, 1908, a total of 101 turbines had been sent out. Most of these were sold by correspondence assisted in some cases by a personal visit. Illustrating the confidence

[1] *Journal of the Western Society of Engineers*, July and August, 1908, pp. 557–558 and 560.

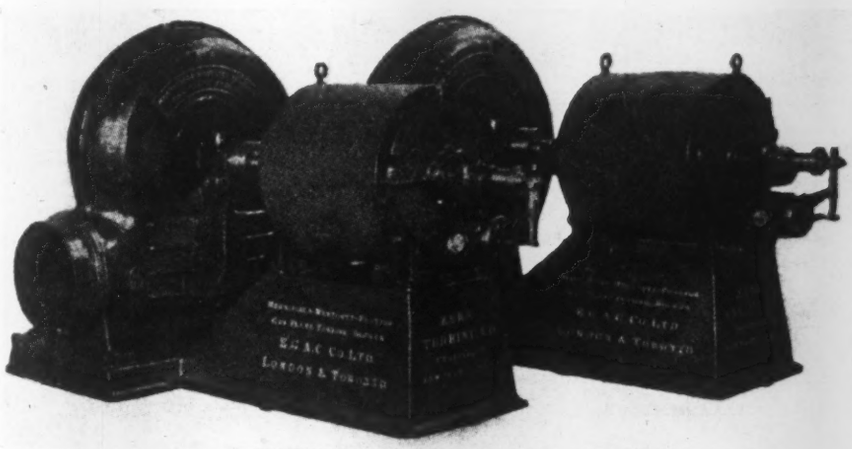
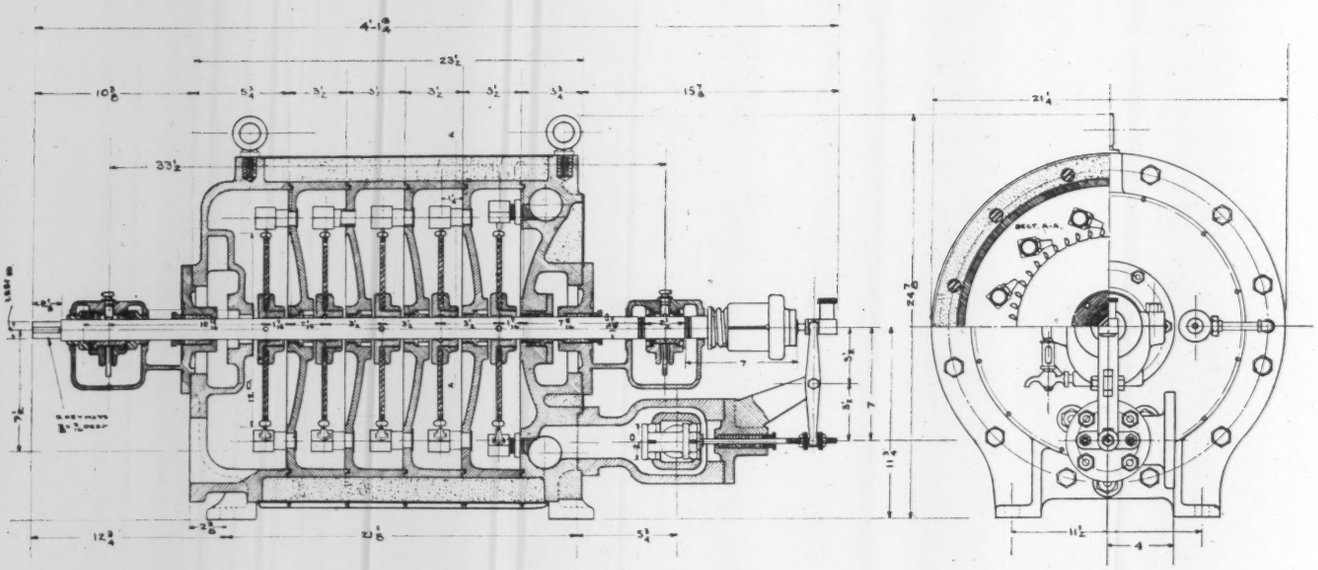
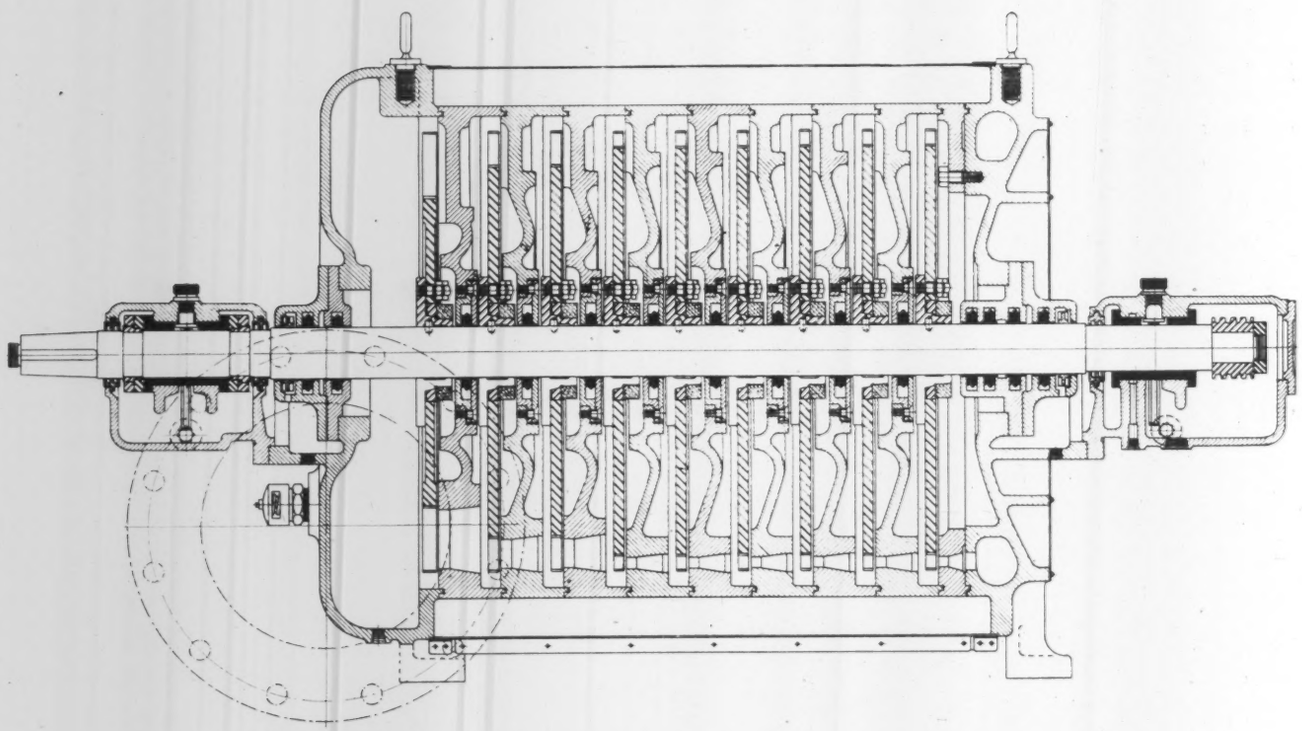


FIG. 3 TWO GAS-BLOWER UNITS THAT WERE SHIPPED TO SCOTLAND



CROSS SECTION OF ONE OF THE EARLY (1907) KERR MULTISTAGE TURBINES IN WHICH THE PELTON TYPE OF BUCKET WHEEL WAS USED



CROSS SECTION OF A LATER TYPE (1914) OF KERR MULTISTAGE TURBINE IN WHICH RADIAL BLADES WERE USED IN THE ROTOR

[The originals of the drawings appearing on this page were supplied through the courtesy of M. A. King, manager, Turbine Department, Elliott Company.]

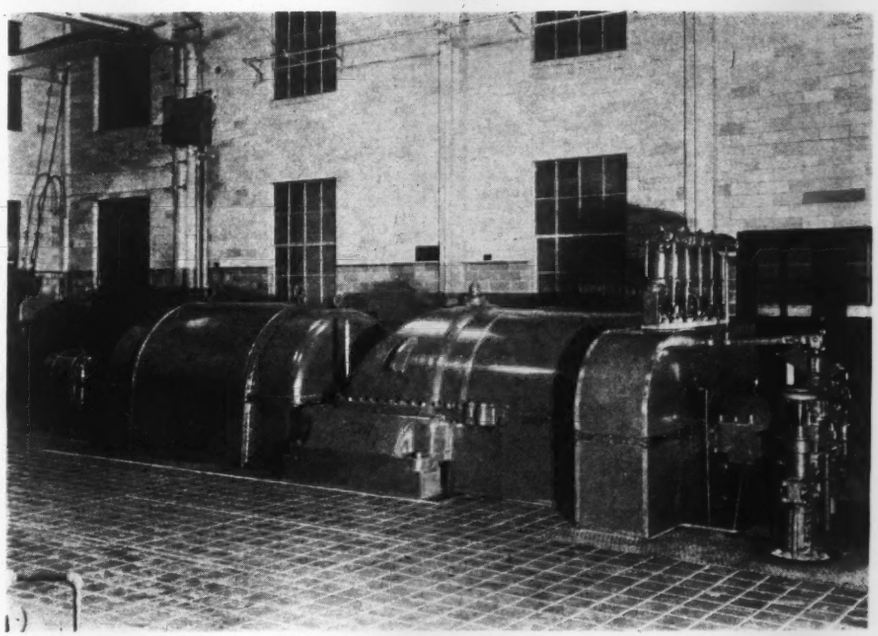


FIG. 4 3000-KW CONDENSING TURBINE GENERATOR MANUFACTURED BY ELLIOTT COMPANY

inspired in buyers by the known policy of shipping units made right for the job, a hydraulic dredging outfit consisting of steam turbine, centrifugal pump, and surface condenser was sold to the Mississippi River Commission entirely by correspondence. Assembly of the product from three builders was made at the shop with test and shipment to destination. Installation and service tests were made at once which confirmed the shop test with performance a good 10 per cent better than the guarantee. Payment in full by check came within 60 days from order.

With the turbine developed in form and the market widening, opportunity came for more workers in the selling field. The common plan of maintaining offices in even the larger cities was not practicable, so the idea was adopted of arranging with engineering salesmen in the commercial centers who had their own offices and handled lines not competing with the steam turbine. A uniform contract was worked out which gave the agent a liberal commission on prices based on cost and fair profit with a larger commission on prices obtained above those. The purpose was to keep the agent on the alert for market level and to please some who liked to play with prices. Commissions were paid, one half on receipt of order and the other half when the purchaser accepted the unit. This kept the agent interested. A number of them accepted an offer to visit the shop and observe methods of building and testing on the basis of agent's time against trip expenses paid by the company.

This step put the Kerr Turbine Company in full swing commercially, but the depression following 1907 and limited working capital finally forced a move to find money. In the course of negotiations the question was raised as to the profits realized in turbine building. Analysis of one month's business by a qualified accountant showed a net profit of 30 per cent. That induced the money to come in, but with it came new management and a change in personnel which induced me to sell out and undertake the development of a high-speed centrifugal pump that a steam turbine could drive. In a short time competition arose in the home town through the organization of the Moore Steam Turbine Corporation under the leadership of J. L. Moore, who was an engineer with some years' experience in turbine design. His fine personality and business activity and local confidence in him made tough going for the old company. Lack of engineering ability in the new management and competition by the Moore turbine resulted, a few years later, in the sale of the Kerr Turbine Company's business and equipment to the Elliott Company of Pittsburgh, Pa. That the turbine has not suffered by the change is indicated by the unit shown in Fig. 4.

The original argument for the small steam turbine driving a blower or pump in a power plant was an exhaust steam that was free from cylinder oil and had a steady flow, neither of which could be said for the steam engine. The turbine illustrated in Fig. 4 is one of the modern condensing units made by the Elliott Company. It is used to drive a 30,000-kw generator.

Commercial conditions prevented the growth of the steam turbine in the time of Hero, or of Branca, or even of Watt. It remained for the twentieth century with its equipment of machine tools and manufacturing methods now so largely under control of educated engineers to give it life and growth. So, whatever my own disappointments may be, I can feel satisfied that my purpose was timely and right and that the original "crazy man's dream" works out into something useful.

C. V. KERR.[2]

False Brinelling of Bearings

TO THE EDITOR:

Mr. Almen's paper[3] is especially valuable as a thorough technical analysis of a common and commonly misunderstood problem. I would like to add several experiences with this problem, giving a distinctly mechanical angle to it and showing how each case was solved with some necessary modifications of Mr. Almen's theory of oxidation.

One must distinguish between a rolling and a sliding effect within the bearing. The latter will produce lapping or false brinelling at a far greater rate. For example, the taper-roller-bearing rear wheel described probably produced most of the difficulty due to an axial sliding under sidesway.

The inner ball bearing of the stack that supports the blade of a controllable propeller is known as a preload bearing and is merely used to keep the large bearings tight at assembly and when traveling at slow speeds. In operation, deflection of the larger bearings leaves this preload bearing loose internally, and the ball is then wedged by centrifugal force against the race shoulder as shown in Fig. 1. Slight radial movement of the propeller squeezes the ball out of this wedge and permits it to reenter, causing a fairly violent and distinctly sliding, not rolling effect, which produces a deep lapping in a relatively short time. Furthermore, the two lapped holes are not opposite each other on the races as would occur if it happened under load but are both

[2] Consulting mechanical engineer, Los Angeles, Calif. Mem. A.S.M.E.

[3] "Lubricants and False Brinelling of Ball and Roller Bearings," by J. O. Almen, MECHANICAL ENGINEERING, June, 1937, pp. 415-422.

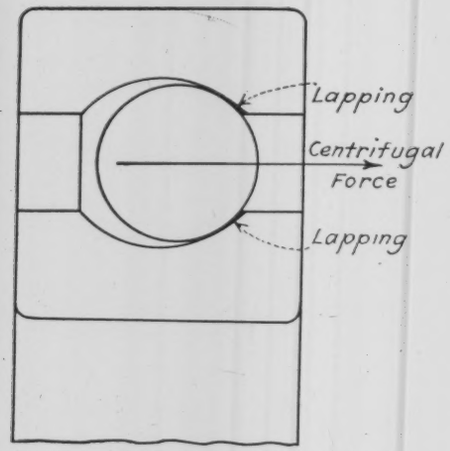


FIG. 1 LAPPING PRODUCED BY CENTRIFUGAL FORCE IN THE INNER BALL BEARING OF THE STACK SUPPORTING THE BLADE OF A CONTROLLABLE PROPELLER

toward the outward side of the bearing where centrifugal force holds the ball. This problem was cured by the simple expedient of leaving no radial looseness within the bearing, so that the balls were not free to move appreciably.

A similar distinction between rolling and sliding was necessary when the same type of microscopic oxidation plus lapping occurred on a sewing-machine motor. In this case, the motor carried a large overhung flywheel, and many motors were mounted on the same table. If several of these were idle while others were running, resulting vibration produced this lapping on the idle motors in several days. This condition was readily reproduced in the laboratory. A large number of tests were made, checking different possible solutions. Lapping could be eliminated by using an angular-contact double-row type bearing, taking all axial play out of the unit. Apparently, radial movement or rolling effect was not enough to cause any harm, but the axial vibration did produce difficulty. The final solution was to continue using the same single-row ball bearing next to the flywheel but to change its internal characteristics so that it could roll up toward the edge of the race. Amplitude of vibration was apparently fixed so that, if enough room was left for the ball to roll axially without crowding to the edge and then sliding, the lapping-oxidation effect did not occur. Incidentally, in this series of tests, we approximately checked Mr. Almen's conclusion, because we tried different lubricants and found that there was not much difference except that a relatively light lubricant showed less difficulty.

Materially increasing bearing capacity largely eliminates the lapping-oxidation effect. This method was used in connection with railroad motors for air conditioning, which are idle for many months in winter, and vibration from the rail produces the same lapping-oxidation effect. It was cured by using a lighter lubricant, again without fully understanding this detail, but it was combined with a change in bearing type to provide a much larger ball capacity. Reduced unit load per ball eliminated most of the lapping-oxidation effect in a way similar to that in Mr. Almen's illustration of the effect of varying loads. Here, also, probably the axial movement that tends to produce sliding rather than rolling did the most damage.

Fig. 2 illustrates an extreme case of this type of lapping oxidation, but the lapping effect is undoubtedly much more serious in this case because of axial movement, since the great depth of lapping would require more than oxidation alone. We believe in this case that the effect was increased by the presence of an EP (extreme-pressure) lubricant that oxidized or sludged and, thereby, increased the lapping effect considerably.

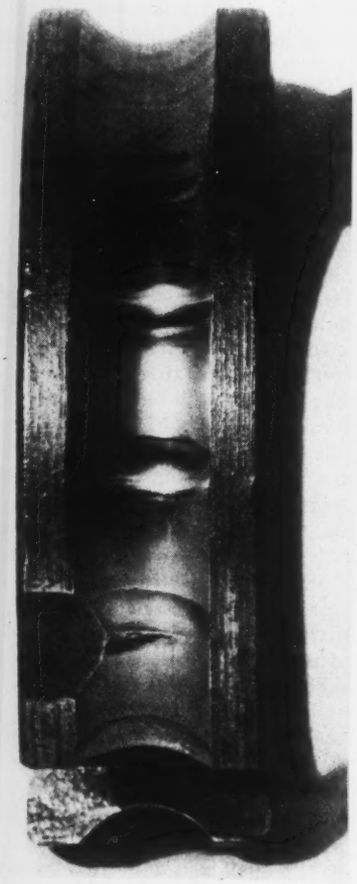


FIG. 2 AN EXTREME CASE OF LAPPING-OXIDATION WHICH WAS AGGRAVATED BY AXIAL MOVEMENT

One other note to Mr. Almen's theory concerns the action on the grease. With rapidly oscillating slight movements in a ball or roller bearing, a very minute quantity of lubricant is lodged in the fine capillary wedge between the ball and the race. Slight rolling of the ball ejects this somewhat forcefully and then sucks it back, and this may be done rapidly and frequently. Practically any grease with a soap base, under this violent agitation without circulation, results in this small quantity of grease at the pocket becoming distinctly rancid. This was best proved by one set of controllable-propeller bearings that were rejected at 150-hour test because of "brinelling." Actually, no brinelling occurred, and, furthermore, practically no lapping either. Pseudo-brinelled areas were considerably larger than usual, and in the center of each area was a small island of the same elliptical shape which had not deteriorated in any way; the initial grinding scratches were practically untouched. Immediately around this island was a distinct acid etching or pitting where the ball had not moved or touched the race but where deterioration of the lubricant had produced a distinct etching. This same condition was produced in almost all of more than 500 ball contacts, definitely proving that the lubricant has a distinct bearing on many if not all instances of this type of false "brinelling."

I wish to express again our opinion concerning the unusual value of Mr. Almen's development, particularly on aeronautic work where parts are light and unit pressures are high and this type of oxidation frequently takes place. One of the most common cases of this type is the seat of a ball and a roller bearing on the shaft. Actual movement under load is aptly described as "fidgeting" and produces a distinct rust-colored oxidation and frequently a notable reduction in size.

THOMAS BARISH.[4]

TO THE EDITOR:

Mr. Barish has added some interesting examples of false brinelling of ball and roller bearings in service. His discussion is especially valuable because he described the remedial measures that were applied in each case.

From our experience the oxidation-

[4] Assistant chief engineer, Marlin-Rockwell Corporation, Jamestown, N. Y.

wear theory seems to explain the observed results better than others that have been suggested, but false brinelling may be due to other causes than oxidation. However, I think that the cases cited by Mr. Barish can be satisfactorily explained without introducing other forms of wear, such as lapping or acid corrosion.

Reduction of oxidation wear by increasing the bearing preload in certain installations parallels our experience. The greater damage that might be expected with increased preload does not occur in some installations where damage is due to relative axial motion of the bearing races, presumably because reduction in amplitude of ball motion more than offsets the effect of the increased load. Increased preload in installations where false brinelling is caused by angular vibration usually aggravates the damage.

The theory that false brinelling of bearings may be due to corrosive action of oil presents some difficulties. Wear patterns, as described by Mr. Barish, in which undamaged areas are surrounded by sharp and relatively deep ditches are not uncommon in service and in test specimens. An excellent pattern of this type was produced during road tests where a 1-in. ball was loaded between two flat surfaces, the assembly being subject to vibration and some variation in load. The oil used was ordinary S.A.E. 20 engine oil. Apparently, the damage is confined to the portions of the bearing surfaces that are alternately loaded and unloaded. For small-amplitude motions, this may be a narrow band surrounding the contact pattern as described. This effect can be seen in several of the specimens illustrated in Figs. 8 and 9 of the paper.

To summarize this discussion:

(1) Acid may or may not cause corrosion or false brinelling of ball and roller bearings.

(2) The acid theory, however, is not necessary to explain false brinelling.

(3) Furthermore, the effect of the absence of lubricant rather than the presence of acid is well illustrated by the tests of lubricant *F*, Table 1 of the paper, which was an experimental lard-oil grease containing free acid. Tests at 70 F showed slight damage. Tests of this same lubricant at 30 and 0 F showed increasing damage as temperatures were reduced, indicating that false brinelling is a function of viscosity of the lubricant and not the acid content.

J. O. ALMEN.[5]

[5] Head, Dynamics Department, research laboratories division, General Motors Corporation, Detroit, Mich.

Surface Broaching in High-Production Industries

TO THE EDITOR: This paper[6] is comprehensive and outlines thoroughly the problems that must be met in making an application of surface broaching, and also covers its history most ably. Messrs. Einstein and Romaine are to be complimented on the thoroughness with which they have covered the subject.

So that designers and users who are not thoroughly familiar with the broaching process may not be under a misapprehension on several points that the authors have stressed, these particular points should be discussed in more detail.

The statement that work must be strong enough to withstand broaching stresses set up is true regardless of the machining method used. Broaches can be designed so that stresses placed on the work are no greater than for any other operation. Stresses must not be compared without taking into consideration the production obtained. If the broaching process increases production between 300 and 400 per cent over milling, boring, or turning, the natural assumption would be that stresses would be increased and must be compensated for. Work must be supported firmly if precision operations are to be performed upon it, regardless of the type of equipment or tools employed. Work cannot have an obstruction in the plane of the surface broached, and, conversely, work can often be broached where obstructions would make it uneconomical to machine by any other method.

On page 333, the statement is made that to remove stock in excess of $\frac{1}{4}$ in. is usually uneconomical and that $\frac{1}{8}$ in. stock is to be preferred as the maximum. Also it is intimated that the increased length of broach required by excessive stock might eliminate the consideration of broaching as a machining method. Messrs. Einstein and Romaine fail to consider side-cutting broaches for parts with excessive stock. This method is being successfully used on main-bearing caps and similar cast-iron parts. With sufficient power in the machine, $\frac{1}{4}$ to $\frac{3}{8}$ in. of stock, or more, can readily be removed. The cuts are started on both sides of the piece and taken toward the center, thus balancing the load. After the excess stock has been removed, the standard method of face broaching may be used to finish the part to dimensions.

The illustrations given cover external work only. Unfortunately, the name "surface broaching" was first given to operations on the outside of the part or to external work, but many internal jobs should also be rightly classed as surface broaching. The first developments in the broaching field had to do with the machining of round, square, and splined holes. As designers have become more familiar with the possibilities of broaching, parts have been designed having internal or external contours which can be economically machined by broaching methods only. A few parts that fall into this field are shock-absorber bodies and wing shafts, door-lock frames, bodies for hydraulic vane lifts, and similar parts. Both straight as well as helical internal and external spur gears are being successfully broached to limits of accuracy that make supplementary operations unnecessary.

After all, the success of broaching is more dependent on the design and accuracy of the tool than upon any other factor. Today, broach manufacturers are equipped to produce these tools to extremely close limits of accuracy and with contours that will produce intricate shapes. Now that the user is becoming broach conscious, a tremendous development in this field can reasonably be predicted.

Broach design is still in its infancy. As better methods of manufacture are developed, greater economy in usage will result. Built-up surface broaches are already the rule, and an endeavor is always made to construct the tool so that the semifinish and finish sections can be progressed forward and ultimately become roughers. This feature of design permits of full usage of the broach material.

In broaching, a knowledge of the machinability of the metal to be cut is of vital importance. As each tooth of the broach passes over the work, the chip that is removed is confined. If the broach is properly designed to suit the metal that it cuts, the chip will form a tight curl, requiring minimum chip space. This, in turn, means an economical broach length.

The principles of broaching as a process of machining materials are not widely understood. Actually, broaching is fundamentally a simple operation, and frank discussions and papers such as this one will tend to clarify the subject.

E. K. MORGAN.[7]

[6] "Surface Broaching in High-Production Industries," by S. Einstein and M. Romaine, MECHANICAL ENGINEERING, May, 1937, pp. 327–333.

[7] American Broach & Machine Company, Ann Arbor, Mich. Mem. A.S.M.E.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of June 25, 1937, which were subsequently approved by the Council.

CASE NO. 840

(Special Ruling)

Inquiry: How shall the thickness of the shell of a wholly spherical vessel be determined and on what basis shall the characteristics of the welded joints in pressure vessels be determined?

Reply: The thickness of the shell of a wholly spherical unfired pressure vessel shall be determined by the formula:

$$t = \frac{P \times R}{2 \times S \times E}$$

where P = maximum allowable working pressure, lb per sq in., and the various other symbols are as defined in Par. U-20*a*,

except that R is to be the inside radius of the sphere in all cases. This formula shall not be used when the thickness of the shell exceeds 20 per cent of the inside radius.

The welded seams of such a vessel shall conform to the requirements of Par. U-73*a*.

CASE NO. 841

(Interpretation of Pars. U-69 and U-70)

Inquiry: Is a welding operator, who has been regularly engaged in fabrication of Par. U-68 pressure vessels, qualified thereby to weld Par. U-69 pressure vessels?

Reply: It is the opinion of the Committee that a welding operator who has been regularly qualified and engaged in welding Par. U-68 pressure vessels is qualified thereby to weld Par. U-69 or Par. U-70 pressure vessels provided the same process and position is employed as that for which the operator has been qualified. Similarly, welding operators qualified for welding Par. U-69 pressure vessels are qualified to weld Par. U-70 vessels. All such qualifications however shall not be effective for more than six months after the welding operators have made qualifying test plates, except as noted in Pars. U-69*a* and U-70*a*, respectively.

CASE NO. 842

(Special Ruling)

Inquiry: Par. UA-21*a* states that the formulas for flanges are suggestive only and not mandatory. Recent developments in methods of flange design indicate that flexibility in some of the other paragraphs is desirable for the advancement of the art. Can modifications of these paragraphs be used in designing flanges forming parts of vessels stamped with the Code symbol?

Reply: It is the opinion of the Committee that pending the adoption of revisions now being studied, the following paragraphs may be used and shall be considered as suggestive only and not mandatory; Pars. UA-17*a*, UA-18, UA-20*b* (so far as the locating of reaction H_D and W is concerned). UA-20*c* (location of bolt reaction), UA-21*a*, and UA-22*d*(2).

CASE NO. 843

(Interpretation of Pars. P-191 and U-72)

Inquiry: Does the restriction in Pars. P-191 and U-72 for the forming of plates by pressure and not by blows apply to fusion welded drums or vessels?

Reply: It is the opinion of the Committee that any fusion welded drums which are to be stress relieved, the edges of the plate may be formed by blows providing this is done while that portion of the plate is at a forging temperature and such forming does not objectionably deface the plate.

CASE NO. 844

(Interpretation of Par. H-78)

Inquiry: In the construction of a locomotive firebox boiler will the welding meet the intent of Par. H-78 of the Code if the wrapper sheet and cylindrical shell are joined by means of a lap-welded joint provided the wrapper sheet is stayed in accordance with the requirements of the Code?

Reply: It is the opinion of the Committee that this type of joint is permissible for the specified conditions, for pressures not exceeding 15 lb steam and 30 lb water.

THIS MONTH'S AUTHORS *and* PAPERS

ELECTRICAL MEASUREMENT OF MINUTE MOTIONS

Mechanical measurements involving displacements as small as 0.00001 in. and even 0.000001 in. can be made with the electric gage which, according to C. M. HATHAWAY and E. S. LEE, is a device for accurately measuring either small dimensions or small variations in larger dimensions. Displacements being measured can be amplified 10,000 or 100,000 times on the indicator without introducing frictional effects, such as hysteresis or sticking. Four methods of electric gaging, capacitance, bridge, saturation, and eddy current, are described in the paper, "The Electric Gage," with examples of applications. Included among these are measuring finished-parts dimensions, stresses and strains in bridge members, and thickness of enamel, paint, and plating films on flat steel surfaces.

Mr. Hathaway was graduated from the University of Colorado with the degree of B.S. in electrical engineering in 1927. The following year he held a research fellowship at the University and received his M.S. degree in 1928. In 1929, Mr. Hathaway was employed by the General Electric Company at its Schenectady, N. Y., plant and was appointed mechanical engineer of the general engineering laboratory in 1934.

After graduation from the University of Illinois in 1913 with the degree of B.S. in electrical engineering, Mr. Lee was an instructor in electrical engineering at Union College, Schenectady, N. Y., for three years. While thus engaged, he studied for the degree of M.S. in electrical engineering which was conferred in 1915. Since 1919, he has been affiliated with the General Electric Company in the general engineering laboratory at its Schenectady plant, being promoted to assistant

engineer in 1928 and appointed to his present position of engineer in charge three years later. Mr. Lee, who is a member of the A.S.M.E., is a Fellow of the American Institute of Electrical Engineers and has just completed a four-year term as a director. In addition to his activities in these two societies, he has been active in committee work of the American Society for Testing Materials and the American Standards Association.

DEVELOPMENT OF NAVAL DIESEL ENGINES

Approximately nine years ago, development of high-speed, lightweight Diesel engines in Germany reached the stage justifying their use as propelling plants of warships and that country has led in the development of this type of engine since then, says E. C. MAGDEBURGER. The high-speed Diesel-engine program of the U. S. Navy was inaugurated in March, 1932, when the necessity of developing 2 hp to propel submarines on the weight formerly allowed for 1 caused the Bureau of Engineering to invite all Diesel-engine builders to submit proposals for the construction of an engine and generator having a weight limit of $27^1/_2$ lb per bhp of the engine. Results attained by the different builders are described in the paper, "U. S. Navy Participation in Diesel-Engine Development," which also mentions application of this combination to supply electrical energy in emergencies, for use in power boats, and in connection with the modernization of auxiliary ships. Research on fuels and elimination of torsional vibration is briefly described.

Mr. Magdeburger, who is an A.S.M.E. member, is a native of Russia and was graduated from the Leningrad Institute in 1909. The summers of 1908 and 1909 were spent as a draftsman on four-cycle M.A.N. Diesel engines at the Kolomna Iron Works. From 1910, when he came to this country, until 1922, Mr. Magdeburger was employed in various capacities by Allis-Chalmers Mfg. Co.; Fairbanks, Morse & Co.; Busch-Sulzer Bros. Diesel Engine Company, where he designed a line of four-cycle Diesel engines for industrial use and two- and four-cycle high-speed engines for submarines; and St. Marys Oil Engine Company in connection with the design, production, and development of oil engines. He has been an aide on Diesel engines in the Bureau of Engineering, Navy Department, for the last 15 years and in this position, which is that of a civilian technical assistant, has served as a consultant on all questions in connection with the design, installation, and operation of Diesel engines in naval vessels and the vibration of both steam and Diesel propelling plants.

AIRCRAFT-ENGINE DEVELOPMENTS

No revolutionary features are apparent in a survey of aircraft-engine developments, the advances, which can be classed under the general headings of fuel and design, being the result of numerous detail improvements in design and materials, according to the article "Developments and Problems of Aircraft Engines." In the fuel field the most important contribution has been the development of high-octane fuel to increase engine power and decrease specific weight and this has been matched in the design field by increased use of magnesium-alloy forgings and castings in low-stress sections. Future improvements, says A. N. TROSHKIN, will include increased supercharging, use of high-octane fuel throughout the operating range, and reduction of engine noise. High-speed geared engines offer possibilities for increasing power output without additional weight but practical problems of gear losses, vibration, materials, and piston velocity versus combustion rate must first be solved.

As an inspector of aircraft materials for the Loening and Chance Vought companies and an instructor at the Valley Stream, N. Y., airport, the author obtained a background that qualifies him to discuss this topic. This experience has been supplemented by teaching in the aeronautical-engineering department at Beekley College and lecturing at Stewart Technical School on topics relating to aircraft-engine theory and practice. Since 1934, Mr. Troshkin has been an instructor in aeronautical engineering at the Daniel Guggenheim School of Aeronautics of New York University and has been in charge of the aircraft-engine testing laboratory.

ECONOMICS OF DRYING FOOD PRODUCTS

In discussing the national economic aspect of the artificial drying of agricultural products, CHARLES W. THOMAS points out that soil reclamation and reforestation necessarily reduce the cultivable areas required by number and average age of the population, diet, and mode of living. More intense cultivation is therefore necessary and artificial drying, which is part of the program for carrying over surpluses and regulating prices, naturally follows.

The author, who is an A.S.M.E. member, is a consulting engineer specializing in the dehydration of food products and part owner of the General Dehydration Company, New York, N. Y. He was graduated from Stevens Institute of Technology in 1884 with the degree of M.E. and became assistant superintendent of the Dixon Pencil Works, Jersey City, N. J. Mr. Thomas has had a broad and varied experience in developing, designing, and constructing machinery for inventors and has lectured at Columbia University, where he was professor of machine design until his retirement in 1934, and at the Newark Evening Technical School.

TECHNICALITIES OF AGRICULTURAL-PRODUCT DRYING

Lower operating costs in drying agricultural products can be achieved in two ways (*a*) improving the utility factor and (*b*) reducing the moisture content. To reduce the quantity of heat required, the paper entitled "Technical Aspects of Agricultural-Product Drying" recommends mechanical separation of the juice and partial drying in an evaporator to thicken it before mixing with the pulp for final drying. Factors limiting drier performance are discussed and the necessity for additional data on the final moisture content and rates of regain are stressed.

ARNOLD WEISSELBERG, who is a member of the A.S.M.E., is a consulting engineer specializing in drying, air conditioning, and power plants, special machinery, and equipment design. He was born in Rumania and studied mechanical engineering at the University of Vienna. After coming to this country, Mr. Weisselberg was employed by a number of companies in the Cleveland, Ohio, area as a draftsman and designer for three years. From 1926 to 1930, he was a designer or sales engineer of combustion appliances with builders of this equipment in the vicinity of New York City and for a consulting engineer at Newark, N. J. For the last seven years, Mr. Weisselberg has been engaged in the practice of consulting engineering with offices in New York.

WHAT NEXT IN ENGINEERING EDUCATION?

With an investigation that was carried out at the University of Wisconsin as a basis, the article, "The Next Step in Engineering Education," proposes broadening the education of engineering students by including more economic, social, and business courses and extending instruction into the period between the completion of a four-year curriculum and graduation and the achievement of professional recognition that comes after several years of practical experience. The author, E. D. AYRES, who is associate professor of engineering economics at the University of Wisconsin, suggests an organized educational procedure of residence instruction at college and correspondence and class instruction through an extension division.

Professor Ayers received an A.B. from Miami University in 1920 and continued his studies at Massachusetts Institute of Technology, receiving an S.B. in electrical engineering in 1922 and an S.M. a year later upon completion of the General Electric cooperative course in electrical engineering. Following graduation, he was a proposal engineer in the switchboard department at the General Electric Schenectady, N. Y., works for seven months and then became associated with Moreland & Jackson, a Boston firm of consulting engineers. This employment continued until 1930 and covered technical studies and cost estimating on a variety of engineering projects. Professor Ayers has been connected with the University of Wisconsin as assistant professor of electrical engineering from 1930 to 1934, assistant professor of steam and gas engineering from 1932 to 1934, and associate professor of engineering economics since 1935. Between 1933 and 1935, he was retained by the Public Service Commission of Wisconsin as a special utilities engineer to investigate the feasibility of a continuous inventory of all public-utility fixed-capital property. He was granted a leave of absence by the University for the 1934–1935 academic year to set up a design for this inventory and also to reorganize the engineering department of the Commission.

VISUAL DENSITY OR TOTAL VOLUME OF SMOKE

Incorporation of Ringelmann-chart procedure for smoke-density determinations in ordinances of American cities has emphasized apparent or visual density of smoke rather than total quantity of soot discharged into the atmosphere which constitutes a greater menace to health, says LIONEL S. MARKS in the article, "Inadequacy of the Ringelmann Chart." In

defense of his statement Professor Marks describes and illustrates several simple experiments that offer convincing proof of them. In his opinion a satisfactory smoke ordinance should insist on a high standard of smokelessness for approximately 90 per cent of the time and permit smoke of stated visual densities that vary with stack diameter and background for the remainder.

The author, who is an A.S.M.E. member, has been professor of mechanical engineering at Harvard University since 1909. He received the degree of B.Sc. from the University of London in 1892 and an M.M.E. from Cornell University two years later. Except for service at the Bureau of Standards and with the National Research Council during the World War, Professor Marks has been at Harvard since 1909. He is internationally known as editor of the "Mechanical Engineers' Handbook," and as coauthor with H. N. Davis, of "Steam Tables and Diagrams." Among other books written by him are "Gas and Oil Engines" and "The Airplane Engine," and a recent translation of a German book on fans.

TRUTH IN RUSSIA

OLIN INGRAHAM, who reviews Sir Walter Citrine's book "I Search for Truth in Russia" in his article in this issue, is a member of the department of economics and social science of the Massachusetts Institute of Technology.

BOOKS RECEIVED IN LIBRARY

AERODYNAMICS. By N. A. V. Piercy. D. Van Nostrand Co., New York, 1937. Cloth, 6 × 9 in., 423 pp., diagrams, charts, tables, $9. This book is intended to provide an undergraduate course in aerodynamics and its immediate application to aircraft, and also to supply advanced information needed by designers and research engineers. It aims to supply an adequate introduction to the reports of research laboratories and important original papers.

AIR CONDITIONING IN THE HOME. By E. Torok. Industrial Press, New York, 1937. Leather, 6 × 9 in., 296 pp., diagrams, charts, tables, $3. This book explains the important advantages of air conditioning, the fundamental principles, equipment and systems in use, and gives definite data for every one interested either in partial or complete air conditioning. Covers the use of psychrometric tables, heating calculations, and the 1937 Standard Code for heating systems.

AIRCRAFT YEAR BOOK FOR 1937. Nineteenth edition. Edited by H. Mingos. Aeronautical Chamber of Commerce of America, Inc., New York, 1937. Cloth, 6 × 9 in., 526 pp., illus., diagrams, charts, tables, $5. This annual publication contains facts and figures, with numerous illustrations, covering world and U. S. air powers, U. S. departments and personnel, notable flights, air lines and airports, aircraft specifications and designs, and many other pertinent subjects.

APPLIED FLUID MECHANICS. By M. P. O'Brien and G. H. Hickox. First edition. McGraw-Hill Book Co., New York and London, 1937. Cloth, 6 × 9 in., 360 pp., illus., diagrams, charts, tables, $3.50. An introductory textbook covering the usual problems of hydraulics. The authors generalize the treatment wherever possible in such a way as to make the resulting equations applicable to the flow of all true fluids. Throughout, the text stresses engineering problems from the standpoint of modern concepts of fluid mechanics.

BÜCHER DER ANSTRICHTECHNIK (Zweites Buch). Vorträge in Veranstaltungen des Fachausschusses. Herausgegeben vom Fachausschuss für Anstrichtechnik des V.D.I. und V.D.Ch. durch die Gruppe "Verbreitung anstrichtechnischer Kenntnisse." V.D.I. Verlag, Berlin, 1937. Paper, 6 × 12 in., 92 pp., illus., diagrams, charts, tables, 7.50 rm. This annual, issued by the Technical Committee for Paint Technology of the Society of German Engineers and the Society of German Chemists, contains the papers presented during 1936. The aim is to present the results of scientific research upon paints, varnishes, and lacquers in a form for practical use. Questions of raw materials, of proper methods of painting for various industrial purposes and for the prevention of corrosion in structures, the testing and inspection of paint are discussed by specialists.

CHROME TANNING PROCESS. (British Leather Manufacturers' Research Association Monograph No. 1.) By E. W. Merry, with a foreword by D. McCandlish. A. Harvey, London; Chemical Publishing Co., New York, 1936. Cloth, 6 × 10 in., 143 pp., diagrams, tables, $4.50. This British book covers the chrome-tanning process from both practical and theoretical points of view. The first part describes minutely the preparation of tanning liquors, the one-bath and two-bath processes, washing, and works control. In the second part are found sections giving the chemistry of chromium salts and various theories used to explain the mechanism of the process.

HENLEY'S TWENTIETH CENTURY BOOK OF FORMULAS AND TRADE SECRETS. Edited by C. D. Hiscox; revised and enlarged; edited by T. O. Sloane. Norman W. Henley Publishing Co., New York, 1937. Cloth, 6 × 9 in., 883 pp., diagrams, charts, tables, $4. The new edition of this useful reference volume has been revised to contain the most modern information available in the subjects covered. The customary buyers' guide and section on workshop and laboratory methods are included as well as two new features: "Useful information concerning the materials called for in the book" and "Common names of chemical substances." Special sections on plastics, cosmetics, and photography follow the main part of the book which covers a wide range of subjects from adhesives to yeast.

DEGREE-DAY HANDBOOK. By C. Strock and C. H. B. Hotchkiss. Second edition. Industrial Press, New York, 1937. Leather, 6 × 9 in., 296 pp., diagrams, charts, tables, $3. A large amount of information of use to designers and operators of heating and air-conditioning installations is presented in this work in tabular form, with instructions for its use. Degree-day data, by months, for 1064 cities; the number of degree days by months in recent years, for 54 large cities; the length and average temperature of the heating season in 411 cities; and similar practical data are given. The book will assist in checking plant efficiency, predicting fuel consumption and solving other practical problems.

DEUTSCHE AUSTAUSCH – WERKSTOFFE. (Schriftenreihe Ingenieurfortbildung, Zweites Heft.) By H. Bürgel. Julius Springer, Berlin, 1937. Paper, 6 × 9 in., 154 pp., illus., diagrams, charts, tables, 6.60 rm. This book is intended to assist the German engineer in finding satisfactory substitutes for materials that must be imported and are therefore economically undesirable. The possibilities of heavy-metal alloys are first considered briefly. Aluminum and magnesium, and their alloys are then given much attention, their properties and working being discussed at length, and their possible uses instead of foreign metals indicated. Synthetic resins, plywood, rubber, and ceramic materials are considered in a similar way.

Deutsches Museum Abhandlungen und Berichte, Jg. 9, Heft 1, 1937. VOM FLOHGLAS ZUM ELEKTRONENMIKROSKOP. By K. Michel. V.D.I. Verlag, Berlin, 1937. Paper, 6 × 8 in., 32 pp., illus., 0.90 rm. A brief sketch of the evolution of the microscope, in which the important steps are indicated. The author is a member of the scientific staff of the Zeiss Optical Works.

DROP FORGING PRACTICE. By S. Johnson and J. Warby. J. B. Lippincott Co., Philadelphia, 1937. Cloth, 5 × 8 in., 106 pp., illus., diagrams, charts, $1.50. This concise manual is the work of two men actually engaged in the production of steel forgings and is intended to supply direct assistance to those engaged in this work. The types of hammers and trimming presses used, the layout of plants, the types of steel used, die design, die setting, furnaces, forging, inspection, and heat-treatment are discussed briefly and practically.

Eidgenössische Materialprüfungsanstalt an der E.T.H. in Zürich, Laboratorie Fédéral d'Essai des Matériaux, Annexé à l'École Polytechnique Fédérale a Zürich, Switzerland. DER BAU VON BRÜCKEN, GERÜSTEN UND HOCHBAUTEN AUS HOLZ IN DER SCHWEIZ. Beilage zum Diskussionsbericht Nr. 5 der E.M.P.A., Erste Ergänzung. Zürich, October, 1936. Paper, 10 × 13 in., illus., diagrams. This report issued as a supplement to Discussion Report No. 5 (1925) of the Federal Testing Laboratory, Zurich, contains some eighty photographs of some old Swiss wooden bridges, together with photographs of noteworthy wooden bridges, scaffoldings and large buildings erected during the last decade. Brief information as to designers and builders is given. The collection is an interesting exposition of the uses of wood in construction.

EIDG. MATERIALPRÜFUNGSANSTALT AN DER E.T.H. IN ZÜRICH LABORATOIRE FÉDÉRAL D'ESSAI DES MATÉRIAUX ANNEXÉ Á L'ÉCOLE POLYTECHNIQUE FÉDÉRALE À ZÜRICH, Switzerland. Berichte Nr. 80, 100, 101 and 102. 1935–1936. Paper, 8 × 12 in., illus., diagrams, charts, tables. These four reports from the Federal Testing Laboratory at Zürich treat the following subjects: No. 80, The importance of resistance measurements of varnish

films, and a contribution to our knowledge of the resistant properties of nitrocellulose films; No. 100, strength and calculation of welded joints in boiler and pipe making, and welded joints in boiler and tank making; No. 101, heat-treated rails; No. 102, basic thermal considerations concerning the coking process.

HANDBUCH DES MASCHINENWESENS BEIM BAUBETRIEB. Vol. 3, Parts 1 and 2. By C. Carbotz. Part 1 published by Julius Springer, Berlin, 1937. 652 pp., 96 rm.; part 2 published by V.D.I. Verlag, Berlin, 1937. 322 pp., about 45 rm. Leather, 7 × 10 in., illus., diagrams, charts, tables. This third volume, in two parts, of a handbook on construction machinery, covers the moving of earth and rock. Part 1 treats of excavating, scraping, and dumping machinery, with examples of large earth-moving projects. A pocket contains many tables of actual dimensions and costs of various machines. Part 2 covers conveying equipment, track construction, and rail-shifting machinery. A comprehensive review of practice, with numerous bibliographies, is provided.

JAHRBUCH 1936 DER LILIENTHAL-GESELLSCHAFT FÜR LUFTFAHRTFORSCHUNG. R. Oldenbourg, Munich and Berlin, 1936. Cloth, 6 × 10 in., 647 pp., illus., diagrams, charts, tables, 20 rm. This yearbook contains the proceedings of the Lilienthal-Gesellschaft, which has taken over the work previously undertaken by the Vereinigung für Luftfahrtforschung and the Wissenschaftliche Gesellschaft für Luftfahrt. The papers here presented include discussions of many scientific and technical problems of aviation and airplane construction, reports on the activities of the technical committees of the Society, and other information.

JIG AND FIXTURE DESIGN, edited by F. D. Jones. Second edition. *Machinery*, New York, 1937. Leather, 6 × 9 in., 350 pp., illus., diagrams, tables, $3. The second edition of a standard treatise on jig and fixture design. Various types of jigs and fixtures are described and their advantages, disadvantages, and particular applications discussed. Special points are noted with regard to increasing the life or usefulness of the part.

LEICHTE DAMPFANTRIEBE an Land, zur See, in der Luft. By F. Münzinger. Julius Springer, Berlin, 1937. Cloth, 8 × 11 in., 112 pp., illus., diagrams, charts, tables, 20 rm. A discussion of the efforts made in Germany, owing to the lack of sufficient petroleum, to develop light steam-power plants for motive power. Explains what has been done and what is in prospect in the application of steam power to land, water, and aircraft.

LIQUID FUELS. By H. Moore. D. Van Nostrand Co., New York; Technical Press, Ltd., London, 1935. Cloth, 6 × 10 in., 263 pp., illus., diagrams, charts, tables, $8. Intended as a concise manual for engineers and chemists, this book covers the main aspects of fuel oils, both for engines and for external combustion. The preparation of these fuels, the relation between their chemical and physical properties and engine efficiency, fuels for various purposes, testing and analysis are considered.

(The) LOCOMOTIVE. By R. Loewy. Studio Publications, Inc., New York, 1937. Cloth, 7 × 10 in., illus., $2.50. This book contains 125 striking photographs illustrating the development of aesthetic design of locomotives. Examples of streamlined locomotives and trains from all over the world are shown, with brief comments by the author, who is responsible for streamlining the two types of locomotives which have been adopted by the Pennsylvania Railroad.

MANNING FORMULA TABLE FOR THE SOLUTION OF PIPE PROBLEMS. By H. W. King. McGraw-Hill Book Co., New York and London, 1937. Leather, 6 × 9 in., 351 pp., tables, $5. The table here presented gives a solution of the Manning formula throughout the range of conditions ordinarily encountered in solving pipe problems. The tabulated values are in inches corresponding to different rates of loss of head and different degrees of roughness, and results can usually be taken from the table directly or by mental interpolation. The table is applicable to all circular conduits flowing full, including sewers and drain tile as well as pressure pipes.

MEASUREMENT OF RADIANT ENERGY. Edited by W. E. Forsythe. First edition. McGraw-Hill Book Co., New York and London, 1937. Cloth, 6 × 9 in., 452 pp., illus., diagrams, charts, tables, $5. A compilation of useful information pertaining to radiant energy and methods of measuring it. The treatment covers the laws of radiation, the radiation constants, the care that should be taken with the source in radiation measurements, and the method of separating radiation into wavelength intervals. Methods of measurement, etc., are considered in the fields of radiometry, photometry, and pyrometry. Twenty-one specialists have collaborated in this book, which is sponsored by the National Research Council. There are bibliographies.

MITTEILUNGEN DES WOHLER-INSTITUTS, BRAUNSCHWEIG, Heft 30. Dämpfungsfähigkeit der Werkstoffe Oberflächendrucken. Resonanz-Schwingungsdämpfer für Kurbelwellen. By O. Föppl. Friedr. Vieweg & Sohn, Braunschweig, 1937. Paper, 6 × 8 in., 58 pp., illus., diagrams, charts, tables, 4 rm. This brochure contains contributions to the problem of vibration in metals. The first is a German translation of a paper on "The practical importance of the damping capacity of metals, especially steels," read before the Iron and Steel Institute in 1936, with some additional notes. A second, upon "Surface rolling," is a discussion of a paper in the *Journal of Applied Mechanics*, Trans. A.S.M.E., 1936. The final paper is upon "Vibration dampers for airplane-engine crankshafts."

OPEN-HEARTH FURNACE, Its Design, Construction, and Practice. Vol. 1. By W. C. Buell, Jr. Penton Publishing Co., Cleveland, Ohio, 1936. Cloth, 6 × 9 in., 276 pp., illus., diagrams, charts, tables, $4. The first of three volumes devoted to a critical study of current American open-hearth furnace design, based upon a series of articles contributed to *Steel* during the years 1932–1935. This first installment treats of the history of the furnace, the economic features of the problem, the available refractories and the transmission of heat through them, the design of the supporting steelwork and the development of furnace hearths, back and front walls, and roofs. The book is apparently the first to discuss critically the design and use of the open-hearth furnace.

PHYSICAL TESTING OF METALS AND INTERPRETATION OF TEST RESULTS. By H. D. Churchill. American Society for Metals, Cleveland, 1936. Leather, 6 × 9 in., 109 pp., illus., diagrams, charts, tables, $2. This book contains five lectures upon the tests for tension, compression, shear, bending, hardness, impact and fatigue, and some special tests in common use. The purpose of each test, the information to be expected from it, the method of applying it, and the analysis of the results are discussed, with the object of clarifying their use and securing greater uniformity. The lectures were delivered before the American Society for Metals.

PRINTING METALS. Edited by Fry's Metal Foundries, Ltd., Tandem Works, London, S. W. 1937. Cloth, 5 × 8 in., 92 pp., illus., diagrams, charts, tables. This little book, which is issued by a prominent English maker of type metal, presents a considerable amount of practical information which is not readily available elsewhere. It gives an outline of the metallurgy of printing metals and of the factors that govern the choice of alloys for particular purposes; considers the general principles of metal casting and the problems of casting type and stereo plates; and offers advice on the care of printing metals during use. Photomicrographs of typical printing metals are shown, and appendixes give useful physical data.

I. SCHWEIZ, KONGRESS ZUR FÖRDERUNG DER HOLZVERWERTUNG, BERN, 1936. Bern, Switzerland. Paper, 7 × 10 in., illus., diagrams, charts, tables. These four pamphlets contain addresses delivered at the First Swiss Congress for Promoting the Utilization of Wood, held at Bern in 1936. Dr. Ros discusses "Wood as a Building Material," describing its structure and mechanical properties. Dr. Schläpfer considers the "Basic Principles of the Combustion of Wood." Dr. O. Stadler reports on "Modern Wood Firing in Small Installations," such as stoves, kitchens, laundries, water heaters, etc. Dr. Tobler considers the "Manufacture and Use of Wood Gas for Motor Vehicles."

(The) THEORY OF GOLD SUPPLY. By W. J. Busschau. Oxford University Press, New York, 1936. Cloth, 6 × 9 in., 193 pp., diagrams, charts, tables, $3.75. An economic treatment of the gold-mining industry, in particular that of the Witwatersrand. The book is mainly concerned with the factors determining grade and rate of gold output, and the influence of taxation or other government intervention on grade and scale of operations. Several appendixes give statistical tables and related information.

WAHRSCHEINLICHKEITEN UND SCHWANKUNGEN Vorträge von M. Czerny, K. Franz, F. Lubberger, J. Bartels and R. Becker. Edited by F. Lubberger. Julius Springer, Berlin, 1937. Paper, 6 × 10 in., 100 pp., diagrams, charts, tables, 8.40 rm. A group of five treatises on the fundamentals, theory, and applications of probabilities and variations.

WAVE MECHANICS, Elementary Theory. By J. Frenkel. Second edition. Oxford University Press, London and New York, 1936. Cloth, 6 × 10 in., 312 pp., diagrams, charts, $6.75. A self-contained exposition of the elementary theory of wave mechanics. There are chapters on light, matter, motion of particles or systems of particles, statistical mechanics, application of the quantum statistics to electron theory, and theory of chemical forces. There are also a number of applications to simple special problems.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

First A.S.M.E. Fall Meeting to Be Held in Erie, Pa., October 4-6

Ten Professional Divisions Cooperating With Erie Local Section in Planning Excellent Program

IN ADDITION to the regular Annual and Semi-Annual Meetings of the A.S.M.E. the Council of the Society has extended its activities to include a Fall and a Spring Meeting.

The first Fall Meeting is scheduled for October 4 to 6 at Erie, Pa., thus offering an excellent opportunity for so many members in that thickly populated section of the country to attend a national convention of the A.S.M.E. Headquarters will be at the Hotel Lawrence.

President Herron and members of the Executive Committee of the A.S.M.E. Council and of the Standing Committee on Local Sections will attend the meeting.

PROFESSIONAL DIVISIONS COOPERATE IN PROGRAM

As will be seen from the detailed program which follows, ten professional divisions are cooperating with the Erie Local Section in providing papers for this meeting. In addition to the twelve technical sessions covering power, railroads, machine-shop practice, fuels, management, processing, petroleum, instruments, and cutting of metals, there will be a banquet, and a number of organized visits to more important plants in Erie.

Program

MONDAY, OCTOBER 4

10:00 a.m.

Power

New Metal for High-Temperature Service, by Roger S. Brown and C. L. Clark

Rehabilitation of Station No. 3 Rochester Gas and Electric Corporation, by R. H. Boas

Railroad

Flexible Mounting of Diesel Engines for Transportation Service, by H. W. Gouldthorpe

Place of Railroads in Modern Transportation, by J. V. B. Duer

Machine Shop Practice

Better Electrical Apparatus with Minimum Welding, by A. P. Wood

Machine-Shop Practice Pertaining to Arc Welding and Steel Fabrication, by A. C. Cochrane

Oil and Gas Power—Hydraulic

Investigation of a Simple Form of Hydraulic Dynamometer, by E. P. Culver

1:00 p.m.

General

Luncheon Meeting: *Speakers*, President James H. Herron and H. L. R. Emmet

2:30 p.m.

Excursions to Erie Forge and Steel Co. and American Sterilizer Co.

8:00 p.m.

General

The Young Mechanical Engineer in the Electrical Manufacturing Industry, by A. R. Stevenson, Jr., and E. E. Parker

TUESDAY, OCTOBER 5

10:00 a.m.

Fuels

Use of Individual Gas Producers for Supplying Process Fuel, by Allen J. Johnson

Burning of Waste Liquors in the Kraft and Soda Paper Industries, by Leslie S. Wilcoxson

Management

Production Planning and Control, with papers by W. A. Barr, E. L. Sheehy, and E. W. Johnston

Process

Steam, Power and Water—Distribution and Use in Manufacture of Sulphite Paper, by R. T. Sternberg

Fundamental Requirements in Residential and Small Commercial-Office Air Conditioning, by George B. Helmrich

Railroad—Machine Tools

The Electric Gage, by E. S. Lee and C. M. Hathaway

Experience With the Dynamic Effect of Locomotives and Cars on Railroad Tracks, F. M. Graham

J. C. Bashioum, Erie

AERIAL VIEW OF ERIE

2:00 p.m.

Excursions to General Electric Company and Hammermill Paper Co.

7:00 p.m.

Dinner Meeting

Speaker: President James H. Herron

WEDNESDAY, OCTOBER 6

10:00 a.m.

Management

Production Planning and Control, by Thomas M. Landy

Present-Day Trends in Wage Incentives, by Merritt Lum

Petroleum

Repressuring and Pumping of Oil in Pleasantville-Tellersville Area, by C. C. Hogg

Geological Phases of Repressuring, by C. B. McClintock

Instruments

Industrial Instruments—Their Theory and Application, by Ed S. Smith, Jr., and C. Owen Fairchild

A Theoretical Approach to the Application of Temperature Controllers, by Edmund D. Haigler

Pressure Responsive Elements, by Paul Exline

Metering of Oil With Positive Displacement and Current Type Meters, by E. M. Cloran

Cutting of Metals

Determining the Tool-Life Cutting-Speed Relationship by Facing Cuts, by Charles Kraus and R. R. Weddell

Power and Forces in Milling SAE 3150 Steel With Helical Mills, by O. W. Boston, W. W. Gilbert, and K. B. Kaiser

2:00 p.m.

Excursions to Oil City, Pa., and to Peninsula State Park and Kahkwa Country Club.

W. A. Ims

GENERAL ANTHONY WAYNE'S BLOCK HOUSE

As an industrial city Erie ranks among the foremost though only of moderate size in population. An idea of the large number of varied industries there may be gleaned from the cover of this issue where an attempt has been made "to cover the waterfront." Many of these plants are of the most modern construction, comparing favorably with plants anywhere in the United States.

Excursion to G. E. Works

The excursions which are being arranged include the General Electric Works which is really a city within itself, including 900 acres of land and buildings in which more than 6400 people are employed, and miles of railway tracks to permit the transporting of materials and supplies from one department to another.

The Erie Works is one of the principal locomotive-manufacturing centers of the country. During the 26 years of its operation in Erie, more than 7000 locomotives of various types have been constructed.

It is also one of the principal electric-refrigerator centers of the country. Its refrigerator department manufactures and assembles 1700 refrigerators a day.

W. A. Ims

CLUB HOUSE AT WHICH LUNCHEONS WILL BE HELD

Other products of the works include gray iron, malleable, and alloy castings; wood and metal patterns; air compressors, refrigerated trucks, railway electric control equipment, dies and other tool equipment.

Plant of Hammermill Paper Company

The Hammermill Paper Company plant will also be visited. Into this plant go spruce logs and out of it comes some of the world's best-known paper. But it is the steps in between that will interest A.S.M.E. members, for this 39-year old mill is one of the most modern in the world in its scientific methods and equipment. During the past five years it has spent several million dollars on new buildings and machinery. So whether a person has ever seen a paper mill or not, this will prove an interesting and enjoyable trip.

Trip to American Sterilizer

Another of the organized trips will be to the plant of the American Sterilizer Company, one of the leading concerns in the world in this industry. It employs about 250 people and manufactures sterilizers, disinfectors, water stills, operating tables, and surgical lights, and maintains an extensive research department.

W. A. Ims

MEMORIAL SHAFT TO COMMODORE OLIVER HAZARD PERRY

Erie Forge & Steel

Still another and equally interesting trip will be to the Erie Forge and Steel Company, a subsidiary of the Erie Forge Company, manufacturers of open-hearth steel forging ingots, billets, forgings, and castings. Of special interest are the open-hearth furnaces ranging in capacity from 50 to 65 tons, the foundry, machine shop, and tool department where there has just been completed the installation of the most modern type crankpin turning tool.

Oil City Excursion

Sixty miles distant from Erie in the beautiful mountain region of western Pennsylvania is Oil City, to which an excursion is being planned. Nearer by and of special interest are Pennsylvania State Park and the Kahkwa Country Club.

A special committee has been working to provide entertainment for the women attending the meeting and still another committee has been working on golf plans. Erie in October should prove an ideal spot for a Fall trip.

Please Send Your Reservations

The cooperation of members who expect to attend this Meeting is requested in the matter of sending advance notice to the chairman of the hotel committee, W. F. Wadsworth, 818 Commerce Building, Erie, Pa. A convenient way to do this will be to send him a copy of your letter to the Hotel Lawrence making your reservation for accommodations. If you do not expect to be present for the entire meeting, please indicate this in your communication. It will also help the local committee considerably if you will state also what reservations you will require for the banquet, the cost of which will be $2.50 a person.

Junior Group Activities

What Are A.S.M.E. Junior Groups Doing?

EFFORTS are being initiated to bring the activities of junior groups in the local sections of The American Society of Mechanical Engineers to the attention of all members of the Society by means of the A.S.M.E. News Section of MECHANICAL ENGINEERING. Officers of these groups are invited to send material of general interest to headquarters.

Kansas City Juniors Have Varied Programs

THE Junior Group of the Kansas City Section of The American Society of Mechanical Engineers meets once a month throughout the year and presents a variety of programs. Some meetings feature members of the group who give reports on personal projects in engineering, review current technical articles, or lead discussions. At other meetings outside speakers are introduced.

The last program of the past fiscal year, held on June 8 in Room 1505 of the Kansas City Power & Light Company Building, covered a discussion on labor conditions, led by Mr. Gurley, and a talking picture on storage batteries presented by Mr. Merrill.

The group's officers and executive committee met during the summer months to plan this year's programs with the purpose of increasing attendance and encouraging Kansas City juniors to meet with other members of the engineering profession.

Metro Junior Group Plans for Coming Year

THE administrative year 1937–1938 marks the fifth year of existence of the Junior Group of the Metropolitan Section of The American Society of Mechanical Engineers, as an organized entity. The first four years of its activity have resulted in the group's becoming a stepping-stone so that student and junior members find it easier to gain a place in the Society as full members with major interests and active parts in affairs of the A.S.M.E.

This year's new executive and administrative committees were at work early in the summer making plans which they hope will result in even greater success than was obtained during 1936–1937. Monthly meetings were held and the general policy formulated under the direction of Chairman W. G. Hauswirth. These were supplemented by the organization of the program, membership, publicity, and seminars committees. Advice and counsel were given by O. B. Schier, last year's group chairman, who will serve during the current year as senior advisor to the group.

The completely revised survey form was mailed to all Metropolitan juniors during the first week in August by the special committee organized for the purpose of sounding the opinions and preferences of the more than 1200 members who make up the group. It was designed to appeal to those who usually ignore questionnaires, and was made easy to read and fill in. At the same time, the form called to juniors' attention the privileges to which they are entitled, and gave them an idea of the nature of the program now being planned for this fall and winter.

Members were also asked to volunteer to present papers at one of the seminars, suggest inspection trips, and offer ideas as to subjects and speakers that would make meetings as attractive as possible.

The group will hold eight main meetings, one each month, which will be designed to interest both seniors and juniors. A second monthly meeting will be devoted to more specialized or technical subjects, either through combined meetings with the present seminars or through junior and guest presentations.

Put More Emphasis on Inspection Trips

The Metropolitan Junior Group will put more stress on the importance of inspection trips in its program during the coming year. The value of such trips in a junior-group schedule was the subject of a discussion led by Chairman W. G. Hauswirth at a meeting of the Executive and Administrative Committee held in the Engineering Societies Building on Tuesday, July 20.

Among the trips suggested were: Ford assembly plant, Edgewater, N. J.; the new Lincoln Tunnel between Weehawken and New York City; a brewery; Rockefeller Center; radio studios; Waterside Station; Hell Gate Station; the mercury-vapor power plant of the Public Service Electric & Gas Company at Kearny, N. J.; and the plant of the Crucible Steel Company of America, Harrison, N. J.

Metro Juniors Issue Report of 1936–1937 Progress

This year's annual report of the executive and administrative committees of the Metropolitan Junior Group comprises 36 typewritten pages and gives a comprehensive picture of the growth and activity of the group during the 1936–1937 administrative year. It includes individual summaries of the policies, objectives, results obtained, and recommendations for future policy of each of the following committees: Executive, program, membership, publicity, employment advisory, study groups, and national defense.

Among the suggestions and recommendations made by the executive committee were the following:

(*a*) That complete personnel be selected for each committee at the time the chairman is appointed.

(*b*) That a further incentive be provided through the establishment of senior counselorships for juniors wishing to discuss their past, present, or future development.

(*c*) That a fund be included in the section's budget for the use of the junior group.

(*d*) That more standing and special committees of the Society appoint junior representatives.

(*e*) That the reading room at Society headquarters be made available during the period between the close of the business day and the opening of the meetings, to provide more sociability among members and improve attendance at meetings.

(*f*) That a member of the Metropolitan Section executive committee be appointed as a senior advisor to the junior group. O. B. Schier was appointed to this office.

The report was issued in June under the direction of the retiring chairman of the group, O. B. Schier.

Hartford Junior Group Publishes "Technical Times"

IN HARTFORD, Conn., the junior group of The American Society of Mechanical Engineers has been carrying on a publishing activity of its own in the form of a paper called the *Technical Times*. The publication contains news notes of the Hartford group, brief technical articles, editorials, and a question-and-answer department. The editor is P. R. de Bruyn, the business manager, S. A. Cooke, and the advertising manager, F. W. Hale. The *Technical Times* was initiated by the Hartford group under the chairmanship of Richard Shaw.

Another Metro Student-Branch Dinner Planned

THE success of the A.S.M.E. Junior Group's dinner to Metropolitan student-branch representatives last October has prompted the Metro juniors to plan a similar affair as part of their program this year. The plans for the affair are to be worked up by Horace G. Oliver, Jr., chairman of the Membership Committee of the group.

Representatives of each of the Metropolitan student branches will be selected from this year's graduating class. A similar procedure was followed last year, when those who attended were asked to volunteer for service on a membership subcommittee formed for the purpose of aiding the following year's graduates in the transition from student to Junior membership.

Ninety officers of the class of 1936, honorary chairmen, and heads of engineering departments represented eight engineering colleges at last year's dinner at the Terra Cotta Room of the Hotel Dixie, New York. Roy V. Wright and J. N. Landis represented the senior members, and together with O. B. Schier, of the junior group, spoke briefly and informally on the relations between the student members and the junior and senior branches of the Society. The toastmaster was Walter W. Lawrence, chairman of the committee on arrangements.

A.S.M.E. Wood Industries Division to Meet at Grand Rapids, Mich., Oct. 8-9

Sessions Scheduled on Gluing, Costs, Sanding, and Machining Operations

THE WOOD Industries Division of the A.S.M.E. is to hold a two-day meeting at Grand Rapids, Mich., on October 8 and 9. The tentative program calls for a session on Friday morning on gluing operations, plant visits in the afternoon, and a costs session in the evening. Saturday morning is to be devoted to plant visits and the afternoon to two sessions, one on sanding, and the other on machining operations. In the evening there will be a dinner with addresses on "Human Engineering," by Dr. A. P. Haake and "The Economics of the Furniture Industry," by F. E. Seidman.

On Saturday noon it is planned to hold a luncheon which it is hoped will be a gathering of all the engineers in the Grand Rapids area.

While the assignment of technical papers to particular sessions has not yet been completed, the program will include the following:

The Economical Application of Lumber Lifts, by Fred H. Meyer

Wastes in Lumber and Veneer Manufacture, by Martin Van Valkenburg

A Study of Hot-Press Technique for Plywood, by Thomas D. Perry and Martin F. Bretl

Progress and Achievement of Hot-Press Plywood Bonding in Europe during the Last Ten Years, by L. M. C. Wegner

Recent Developments in Resinous Gluing, by E. H. Merritt

An Investigation of Wood Sanding With Abrasive Belts, by A. M. Isaacson

The Effects of Speed and Pressure on the Cutting Rate of Coated Abrasive Products, by E. T. Hager

An Investigation in the Machining of Woods, by E. M. Davis

A Method of Rating Comparative Machinability of Woods, by A. R. Tegge, Jr.

A.S.M.E. Calendar

of Coming Meetings

October 4-6, 1937
National Fall Meeting (See p. 710)
Erie, Pa.

October, 7-8,1937
Wood Industries Meeting
Grand Rapids, Mich.

October 15, 1937
Textile Meeting
Boston, Mass.

October 27-28, 1937
Joint Meeting of A.S.M.E. Fuels and A.I.M.E. Coal Divisions
Pittsburgh, Pa.

December 6-10, 1937
Annual Meeting
New York, N. Y.

March, 23-25, 1938
National Spring Meeting
Los Angeles, Calif.

June 20-24, 1938
Semi-Annual Meeting
St. Louis, Mo.

A.S.M.E. Publishes Supplement to Management Bibliography

THE AMERICAN Society of Mechanical Engineers has recently published the third bibliography of management literature prepared under the auspices of the A.S.M.E. Management Division. This publication, which is entitled "Supplement to Management Bibliography," is now on sale at a price of $1.50 per copy, and copies are obtainable from the Publication Sales Department, A.S.M.E., 29 West 39th Street, New York, N. Y.

The first management bibliography was issued in 1927 and contained about 2000 items. It represented possibly 50 per cent of the material that had been published on management during the preceding twenty-five years in American and Canadian periodicals and books, and in books published in Great Britain. Four years later these references were combined with more than 2500 additional ones and published, together with an author index, in a book of nearly 150 pages. The present supplement to this book adds another 2500 items to the bibliography, bringing the references up to the year 1936. An author index is also provided.

In all these publications the items are classified by subjects and arranged alphabetically under each subject.

The bibliographies have been compiled by Miss R. M. Berg, who was greatly aided in her work by the use of the files of the American Management Association and The Engineering Index.

A.S.M.E. Textile Division Meets in Boston, Oct. 15

THE TEXTILE Division of the A.S.M.E. is planning a one-day meeting in Boston for October 15 and while the program is still in its tentative stages, nevertheless the papers scheduled thus far give promise of attracting a large group of interested members for the discussion.

The papers to be presented at a session in the afternoon are:

Recent Developments in Wet Finishing and Dyeing Machinery, by Riggs Lombard

Recent Developments in Drying of Textiles, by B. R. Andrews

The Use of Superheated Steam for Drying

Future of the Cotton Spindles in the United States, by A. W. Benoit

There will be an inspection trip in the morning and luncheon will be served in the North Hall of the Massachusetts Institute of Technology.

Exhibit of Photography for Engineers at 1937 A.S.M.E. Annual Meeting

Prints Will Be Received Between November 1 and 26

THE Photographic Group of the A.S.M.E. National Committee will sponsor the second of two annual exhibits of pictorial photography for engineers at the Annual Meeting of the Society in December in New York. An invitation is extended to the entire Society membership to submit prints, either pictorial or technical.

The editor of MECHANICAL ENGINEERING will be entitled to free use of any print for the cover or inside pages, with proper acknowledgment.

The following instructions will assure a measure of uniformity and safe return:

(1) The group will hang at least one print from each contributor. Space limitations may prevent hanging more than four from any one contributor. Mounts should be light-colored, simple cards, either 15 × 20 in. or 16 × 20 in. The use of rubber cement is suggested. Place title of picture and name of maker in pencil on the front of the mount beneath the print. The name and return address of the maker should appear on the back of the mount.

(2) The prints should be securely wrapped and protected with corrugated strawboard. To avoid payment of first-class postage, all letters should be sent separately or attached to the outside wrapping. Inclose remittance for fifty cents to cover return handling postage and insurance. Prints may be called for in person. While the group will exercise all reasonable care in the handling and return of prints, liability will be limited to parcel-post insurance if returned by mail.

Address all prints: John F. Guinan, Annual Photographic Exhibit, A.S.M.E., 29 West 39th Street, New York, N. Y.

Prints should not be sent earlier than November 1 or later than November 26. The Annual Meeting occurs the week beginning December 6, 1937.

The Members' Page

A Forum for Frank Discussion by A.S.M.E. Members

Proposes Unified Society for Welfare of Engineers

THE MEMBERS' PAGE:

I have read Mr. Larkin's letter on "The A.S.M.E. and the N.S.P.E.,"[1] and feel that such comments are very timely. I want to go further and present the problem from another angle.

The World War developed our industrial system to a height comparable to none. The engineering profession was called upon to do its utmost in developing this system and without any question has done a splendid job. The demand for engineers was much greater than the supply, and the colleges were called upon to produce engineers in large numbers. As the fields of engineering became more diversified there ensued a departure from the one-time broad engineering education into specialized schools of engineering. Before the World War we had, in this country, four fields of engineering: Mining, electrical, civil, and mechanical. With the development of new industries engineers became specialists in those industries and comprised subdivisions of the four just mentioned branches of engineering, forming approximately 99 different engineering societies throughout the country. With a membership divided by 99 engineering societies it is hard for the public to recognize any one of these societies as the principal representative of the engineering profession.

Fifteen years ago a movement was started in the State of New York to recognize the engineer legally and give him a definite professional status. This movement was regarded by a majority of engineers as a rather childish, foolish move which had no definite objective and would have no definite value in the future. As time went on the movement gathered momentum, grew in size in the State of New York, and today the engineer is legally recognized in some 33 states of the Union. Many engineers have applied and received their licenses either through the "grandfather" clause or by taking certain examinations. About a year ago a National Society of Professional Engineers was organized with subdivisions of state and county societies. At present this society has as its aims the promotion of the engineer before the public, and the improvement of the engineer's economic status.

During this time the four Founder Societies maintained their original purpose of disseminating technical information to its members. By joint action through the American Engineering Council the Founder Societies have tried to represent the engineering profession to the federal government whenever certain federal engineering problems arose.

During the last depression, when economic production had a severe setback, the Founder Societies were helpless to do anything for the thousands of engineers who, through no fault of their own, found themselves out of work. The Founder Societies were in no way prepared to cope with the situation because their purpose as originally determined was that of disseminating technical knowledge and not of promoting the economic status of the engineer. The Professional Engineering Society, on the other hand, took advantage of the situation and fought, under most trying circumstances because of small numbers and poor financial condition, to help those engineers who found themselves unemployed. There has been, from time to time, bitter comment on the inactivity of the Founder Societies in coming to the aid of and fighting for those unfortunate engineers.

The National Society of Professional Engineers today claims that it is not interested in the dissemination of technical information. But as its membership increases it will be difficult to stand aloof and not to compete in programs similar to those of the Founder Societies. At the present moment, if one were to look ahead, he might foresee with some fear a bitter struggle for predominance in the engineering field between the National Society of Professional Engineers and the Founder Societies. It might parallel the present struggle between the A.F. of L. and the C.I.O. We, as engineers, should not follow such an example but should try to prevent it.

There is only one solution of this problem. We cannot overlook the economic status of the engineer. We cannot overlook the dissemination of technical information. Therefore, let us combine the two. Let us not look for personal laurels. Let us discover what is best for the profession as a whole in years to come. A natural organization for the engineering profession will be one main engineering society in which all its members will be licensed professional engineers or of equivalent standing with subdivisions of groups such as professional, civil, mechanical, mining, electrical. The professional division would take care of the economic and public recognition of the engineer, whereas the other subdivisions would take care of the dissemination of technical knowledge according to the specialized fields of engineering in which its members are interested. Under such a society there would be no duplication of effort. The engineers would be recognized as one main body before the public. The present facilities and the present staffs could continue in office and the engineers would be able to act under any emergency and under all circumstances as one united group.

We have before us excellent examples of unification in the medical and legal professions and the prestige they have gained for themselves, their work, and their opinions by such unification.

This movement must come from the membership as a whole and calls for serious consideration and organization by the engineers. It is hoped that immediate action will be started through comments to MECHANICAL ENGINEERING or other magazines, as well as through organization of engineers in small communities toward the furtherance of this activity.

C. A. HESCHELES.[2]

[1] See MECHANICAL ENGINEERING, August, 1937, page 637.

[2] Brooklyn Union Gas Co., Brooklyn, N. Y. Mem. A.S.M.E.

Other Engineering Activities

Society of Rheology to Meet in Akron, Ohio

AKRON, Ohio, has been chosen for the ninth annual meeting of the Society of Rheology, on October 22 and 23, with headquarters at the Hotel Mayflower.

A member society of the American Institute of Physics, the Society of Rheology is a relatively small group concerning itself with the flow of matter under stress. Specific properties studied include viscosity, plasticity, consistency, elasticity and others of like nature.

Selected Bibliography of Engineering Subjects

THE Committee on Professional Training of the Engineers' Council for Professional Development has just published five pamphlets which, taken together, should prove helpful to those in search of competent guidance in engineering literature. Primarily intended to aid the beginning engineer in choosing his reading, the lists should also be of service to librarians as guides in book purchasing.

The bibliography appears in five sections: (1) Mathematics, mechanics and physics; (2) aeronautical and civil engineering; (3) chemical and industrial engineering; (4) electrical and mechanical engineering; (5) metallurgical and mining engineering. The choice of works has been confined to current American publications and, in general, to those of college grade. Annotations are provided.

These lists represent the considered opinion of a large numbet of teachers and professional engineers, which gives them an authority above any others known to the present writer. The separate pamphlets can be had for ten cents each, or for five cents in lots of fifty, assorted if desired, by writing to the E.C.P.D., 29 West 39th St., New York, N. Y.

HARRISON W. CRAVER.[1]

Prof. H. P. Hammond to Succeed Dean Sackett at Penn State

FRIENDS of Dean R. L. Sackett, who retired on July 1 of this year as dean of engineering of Pennsylvania State College, will be interested in knowing that Prof. H. P. Hammond, head of the civil engineering department at Polytechnic Institute of Brooklyn, has been appointed to succeed him.

Professor Hammond, who was president in 1936–1937 of the Society for the Promotion of Engineering Education, has for many years been interested in the work of that organization, directing the Summer Schools for Engineering Teachers from 1927 to 1933, and serving as associate director of investigation of education for the S.P.E.E. from 1924 to 1927. He has been actively associated with the Engineers' Council for Professional Development as a member of the executive committee and of the Committee on Engineering Schools.

[1] Director, Engineering Societies' Library, New York, N. Y.

Welding Society Publishes Standard Welding Symbols

REALIZING that welding cannot take its proper place as an engineering tool without means being provided for conveying full information from designer to workmen, the American Welding Society has evolved and published a set of standard welding symbols covering both fusion and resistance welding.

These symbols provide the means of placing complete welding information on working drawings. They are picture-writing symbols, showing graphically the type of weld required. In evolving the symbols, the need for simplicity has been kept in mind and the general principle has been followed of having the most common form of any weld require a minimum of numerical data. In final form, the scheme amounts to a shorthand system whereby a large amount of information may be transmitted with a few simple lines and figures. Complete information may be had from the American Welding Society, 33 West 39th Street, New York, where a printed bulletin containing a detailed explanation of the system and instructions for its use is available at twenty-five cents a copy.

Fall Foundry Conference at Battelle Institute

SPONSORED by the American Foundrymen's Association in cooperation with Battelle Memorial Institute, a conference devoted entirely to technical subjects will be held at the Institute laboratories, Columbus, Ohio, September 30 and October 1. While differing in some measure from previous joint conferences of the Association arranged with technical schools, local chapters of its own and other engineering and educational societies, the program, which is nearing completion, will be directed along foundry metallurgical lines. Metallurgists and educators versed in the technical phases of foundry production will deliver papers under the three main headings of steel, nonferrous metals, and gray cast iron. Attendance and participation of the foremost authorities gives opportunity for a practical short course in these subjects to all interested.

Meetings of various A.F.A. committees are being scheduled for Thursday morning, and the formal program will be held Thursday afternoon and Friday. A dinner with short addresses will be held Friday evening.

H. J. Gough, British Authority on Fatigue of Metals, Honored at Luncheon

ABOUT twenty engineers and members of engineering societies and organizations met for a luncheon at the Engineers' Club, New York, N. Y., on July 29 in honor of Dr. H. J. Gough, of the National Physical Laboratory, Teddington, England.

Greetings From the I.M.E.

With Roy V. Wright, past-president of The American Society of Mechanical Engineers, presiding, Dr. Gough brought to American engineers the greetings of the Institution of Mechanical Engineers. He spoke appreciatively of his professional friendships and contacts with scientists and engineers in this country and of some of his impressions of a two months' trip here which he had been enjoying. Informal conversation among the guests drew forth Dr. Gough's explanation of the methods by which British engineering societies pass on the eligibility of prospective members of their organizations and of differences in these methods and those practiced in this country.

Discussion also centered around the need of engineers, particularly those engaged in design, for the perspective and sense of proportion and form that experience in shops provides, and of the importance of such experience in providing the balance and breadth of view that formal education in scientific and engineering subjects alone cannot give.

A copy of J. W. Roe's recent biography of James Hartness, inscribed with the signatures of those attending the luncheon, was presented to Dr. Gough. In accepting the gift Dr. Gough said that while he would always remember the luncheon without it, the book would serve to bring back more vividly pleasant memories.

Attended Meeting of A.S.M.E. Divisions at Ithaca

During his visit to this country Doctor Gough addressed the joint meeting of the A.S.M.E. Hydraulic and Applied Mechanics divisions in June at Cornell University, and the Division of Mechanical Engineering of the Society for the Promotion of Engineering Education at its 1937 meeting in Cambridge.

Dr. Gough served his engineering apprenticeship with Vickers Ltd., from 1909 to 1913. His service with the National Physical Laboratories, which began in 1914, was interrupted by the War. Internationally known for his work on the fatigue of metals, he was Cantor Lecturer to the Royal Society of Arts in 1928, Autumn Lecturer to the Institute of Metals in 1932, and Edgar Marburg Lecturer to the American Society for Testing Materials in 1933.

Seventh International Management Congress to Be Held in Washington, D. C., Sept. 19 to 23, 1938

W. L. Batt, Past-President A.S.M.E., Directing Coordinating Committee

THE SEVENTH International Management Congress, bringing to the United States authorities on industrial and commercial management from about forty countries, will be held in Washington, D. C., Sept. 19 to 23, 1938, with Lord Leverhulme of Great Britain as president, it has been announced.

The Congress will consist of discussions of the latest developments in management, and the social and economic aspects of management, based on more than 200 papers, selected competitively from experts all over the world. Six sections, running simultaneously, will deal with management problems in production, administration, distribution, personnel or labor relations, agriculture, and the home. Leaders of prestige in American business and business abroad will take part in the discussions, together with invited governmental representatives.

The Congress, the first to be held in the United States, is being directed by a coordinating committee, with William L. Batt, past-president A.S.M.E., and president SKF Industries, as chairman. It is launched by the National Management Council with the cooperation of the following organizations: American Management Association, The American Society of Mechanical Engineers, The Association of Consulting Management Engineers, International City Managers' Association, Life Office Management Association, Personnel Research Federation, and Society for the Advancement of Management.

It was announced that in connection with the Congress extensive tours for foreign visitors would be arranged through the plants and offices of industrial and commercial establishments, noted here and abroad for their application of scientific management principles.

The personnel of the American Congress organization was announced in part. Four vice-chairmen of the coordinating committee are Harry Arthur Hopf (Mem. A.S.M.E.) of New York, N. Y., managing partner of Hopf, Kent, Willard & Co.; William H. Gesell, (Mem. A.S.M.E.), executive vice-president of Lehn & Fink Products Co., Bloomfield, N. J.; Thomas R. Jones, president and general manager, American Type Founders Company; and Henry P. Kendall, president, The Kendall Co., Boston, Mass.

Sectional chairman include James O. McKinsey, chairman of the board, Marshall Field & Co., for administration; Ralph E. Flanders, past-president, A.S.M.E., and president, Jones & Lamson Machine Co., for production; Leon C. Stowell, executive vice-president, Underwood-Elliott Fisher Co., distribution; W. W. Kincaid, governing director, Spirella Co., for agriculture; and Marie M. Meloney, editor, *This Week*, for the home.

American Engineering Council

The News from Washington

Coal Price Fixing Is Here

TWENTY-THREE district boards of code members managed by the National Bituminous Coal Commission in the Investment Building at 15th and K Streets, N. W., Washington, D. C., came into existence on June 21, 1937. All are authorized by the Guffey or Bituminous Coal Act of 1937. The principal objectives are the establishment of marketing rules and regulations, fixing minimum and maximum prices, and the prevention of unfair competition in the bituminous-coal industry.

The Bituminous Coal Act of 1937 also created a Consumers' Counsel to provide protection for all consumers of bituminous coals in the United States. The Consumers' Counsel has established headquarters in the Tower Building at 14th and K Streets N. W., Washington, D. C. "It shall be the duty of the Consumers' Counsel to appear in the interest of consuming public in any proceedings before the commission, to offer testimony, examine witnesses or parties to the proceedings," and to have the commission certify to information or conduct investigations of conditions believed to be responsible for unfair consumer prices.

The American Engineering Council has been asked to assist both of these agencies with the location of engineer executives experienced in the several phases of the bituminous-coal industry and invited to cooperate in bringing the objectives of these regulatory bodies to the attention of all engineers connected with or interested in bituminous-coal production, distribution, and consumption. Both agencies are seeking engineering advice and assistance with efforts about to be made with the intention of improving fuel conditions in the public welfare.

Copies of the Bituminous Coal Act of 1937, the Bituminous Coal Code, Taxes on the Sale or Other Disposal of Bituminous Coal and Rules of Practice and Procedure Before the National Bituminous Coal Commission may be obtained directly from the agencies named, from the National Coal Association in the Southern Building or from the Government Printing Office in Washington, D. C. The Counsel and the Commission invite correspondence and cooperation calculated to improve the present bituminous-coal situation.

Engineering Employment Possibilities

EXPERTS in the production, distribution, and use of bituminous coals are being mobilized by both the National Bituminous Coal Commission and the Consumers' Counsel created by The Bituminous Coal Act of 1937. Engineers who are interested should address Commissioner C. E. Smith of N.B.C.C., Investment Building, Washington, D. C., or Ellery P. Gordon of the Consumers' Counsel of N.B.C.C., Tower Building, Washington, D. C. Junior and senior engineers are being employed by both organizations.

Civil-service rules are being applied to junior positions and political sponsorship is required for expert and executive candidates. Civil-service salary schedules have been adopted for all employees. The executives who are making personnel selections are stressing the value of practical experience and most positions call for college graduates. In addition to the staff for the Washington offices, 26 field offices are being organized in the soft-coal producing and consuming areas. Addresses are not available but firms in the coal business will soon know the location in each community.

Specifications for engineers demand experience in coal cost accounting, actual experience in the wholesale marketing of bituminous coals, practical experience in distribution of soft coal to industrial consumers including handling and stocking practices, and an understanding of transportation and traffic problems; or engineering experience in one or more of the several phases of mining, preparation, marketing including transportation, industrial, and domestic use, and the allied industries.

Engineers for WPA Service

IN RESPONSE to a number of complaints from several states to the effect that the WPA was appointing nonengineers to positions which should be filled by engineers, the American Engineering Council took the matter up with the Works Progress Administration and urged that steps be taken to correct the increasingly dangerous practice. After several staff discussions, Col. F. C. Harrington, assistant administrator and chief engineer, has offered the following suggestions which seem worthy of careful consideration and practical application:

It seems desirable to point out in this connection that the responsibility for the engineering and architectural design of all work undertaken by the Works Progress Adminis-

(*Continued on page 718*)

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tration rests upon the local governmental units sponsoring the projects. For some projects the sponsors furnish all necessary supervision, but in any event they have the further duty of assuring themselves that the work is being performed in accordance with their plans and specifications. There has been a great deal of difficulty in getting sponsors to make the proper provisions for carrying out these responsibilities, and anything that your organization can do to improve conditions in this respect will be appreciated.

Under these conditions, the functions of the Works Progress Administration are similar to those of a general contractor, and the effort has been to secure men in responsible positions who have had practical experience in the organization and operation of construction work, rather than engineers who have specialized in design. The ideal man is, of course, the qualified professional engineer who has had the desired practical experience, but it is becoming increasingly difficult to secure or to hold such men at the salaries which it is possible to pay in a work-relief program. The local affiliates of your organization can be of service to the state and local Works Progress Administration by the preparation of lists of men who are known to be properly qualified, who are in sympathy with the purposes of a work-relief program, and who will accept employment at the salaries offered. I am sure that the state administrators will be very grateful to have such cooperation.

In states where unsatisfactory conditions are believed to exist with respect to engineering practices, it would be helpful if the local engineering societies affiliated with the American Engineering Council would take up these matters with the state administrator or the state director of operations. In case this action is impracticable or does not bring about the results hoped for, I will be glad to give consideration to any specific cases which you care to bring to my attention.

Who's Who in Engineering

ENGINEERS and engineering organizations have a directory and biographical dictionary in the Fourth Edition of "Who's Who in Engineering" which has just been published by the Lewis Historical Publishing Company, Inc., New York City. It is well done and a most excellent reference volume. In addition to the biographical dictionary this issue carries a comprehensive list of engineering organizations in the United States and brief descriptions of each of several functional instrumentalities of engineering societies.

Survey of Engineers and Engineering

"SECURITY of Employment in the Engineering Profession" is the title of the fourth of a series of summary articles covering the results of the survey made by the Bureau of Labor Statistics at the request of the American Engineering Council. Although this article is based on the data supplied by only 35,559 of the engineers who responded to the survey questionnaire, it seems to be a fair sampling of experience and presents some interesting information regarding the medium through which engineers find positions, the extent of the use of employment contracts, and engineers patent privileges.

A résumé of this report was published in the August, 1937, issue of MECHANICAL ENGINEERING, pages 609 to 611.

See Your Consulting Engineer

FROM the Los Angeles Engineering Council has been received a copy of a resolution commending a manufacturer of comfort cooling equipment on a circular letter in which it is stated that the company feels that the buyer of such equipment "would benefit in most cases by employing a consulting engineer to prepare plans and specifications." The circular letter further states that "in the best interests of the industry our future advertisements will include the caption: See your consulting engineer." The resolutions included the statement that a copy of them and of the circular letter be distributed to the members of the Council and to the officers of the Founder Societies.

J. C. Bashioum

AN AIRPLANE VIEW OF PRESQUE ISLE STATE PARK, ERIE (SEE PP. 710–711)

Positions Available

Engineering Societies Employment Service

POWER PLANT ENGINEER, 30–35, whose experience has all been in steam and electric distribution and usage. Salary, $275–$300 a month. Apply by letter. Headquarters, East. Y-1760.

DESIGNER, mechanical engineer, 30–40, for automobile tires. Must be expert draftsman with tire-designing experience, and have ability to get in touch with major executives and producing department heads. Salary, $350–$500 a month. Apply by letter. Location, Middle West. Y-1794-C.

EXECUTIVE to supervise design and manufacture of small motors. Engineer with experience in electric-razor field desired. Salary, $6000 a year. Apply by letter. Location, Connecticut. Y-1811.

ASSISTANT SUPERINTENDENT, about 35, with experience in manufacture of fractional- and integral-hp motors in factory employing about 300. Must be able to produce results in production. Apply by letter. Location, Middle West. Y-1823-C.

MECHANICAL ENGINEER, 40–55, to take entire charge of mechanical department on small railroad employing about 75 men in maintenance of 11 locomotives and several hundred units of equipment. Must have at least 15 years' experience in above capacity. Should have technical knowledge of design and construction of locomotives and cars, and must be familiar with modern shop practice, I.C.C. boiler laws and regulations, Association of American Railroad rules and practices generally governing cars and equipment. Must also have office experience as he will be responsible for accounting in his department and office duties such as payrolls, correspondence, drawings, inventory of material and supplies, etc. Apply by letter. Location, South. Y-1827.

EXECUTIVE with experience in Diesel-engine power-plant layout for industrial plants. Must be an experienced Diesel engineer. Apply by letter. Location, New York, N. Y. Y-1858.

MECHANICAL ENGINEER with economic knowledge and diversified industrial background. Must be able to prepare releases for trade publications, and have thorough knowledge of technical German. Salary, $7500 a year. Apply by letter. Location, New York, N. Y. Y-1861.

DEVELOPMENT ENGINEER. Must have experience in design or development of industrial sewing machines. Experience in family type of machine will not be considered. Should be creative and have ability to work out mechanical details of new ideas. Should hold patents if possible. Salary, $5000 a year. Apply by letter. Location, East. Y-1905.

CHIEF ENGINEER, 35–40, married, with experience in design and application of power transmission in particular and gears and speed-reducing units in general. Apply by letter. Location, East. Y-1946.

MECHANICAL ENGINEER with experience in cement plants. Must have experience in firing of pulverized coal in rotary kilns and in

(*Continued on page 720*)

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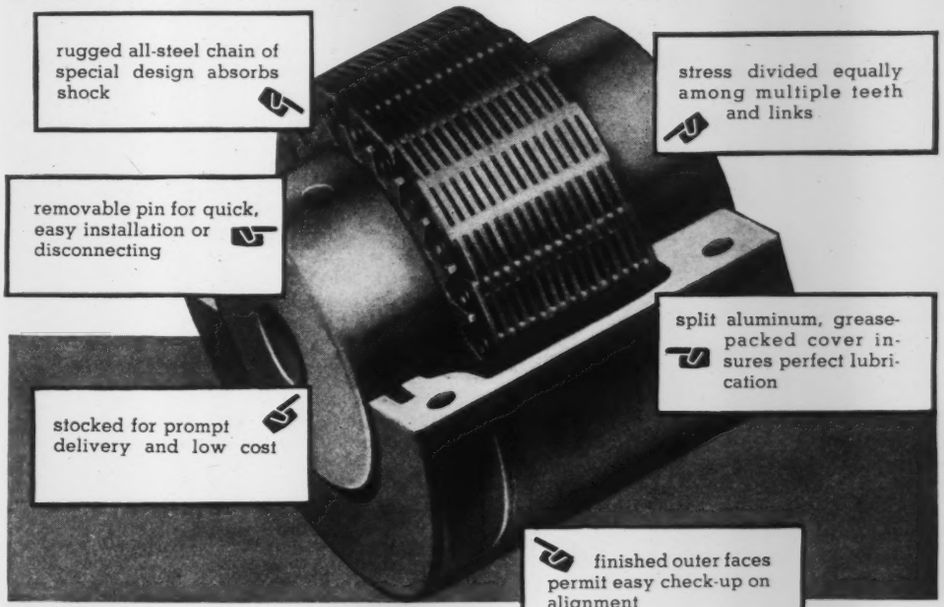
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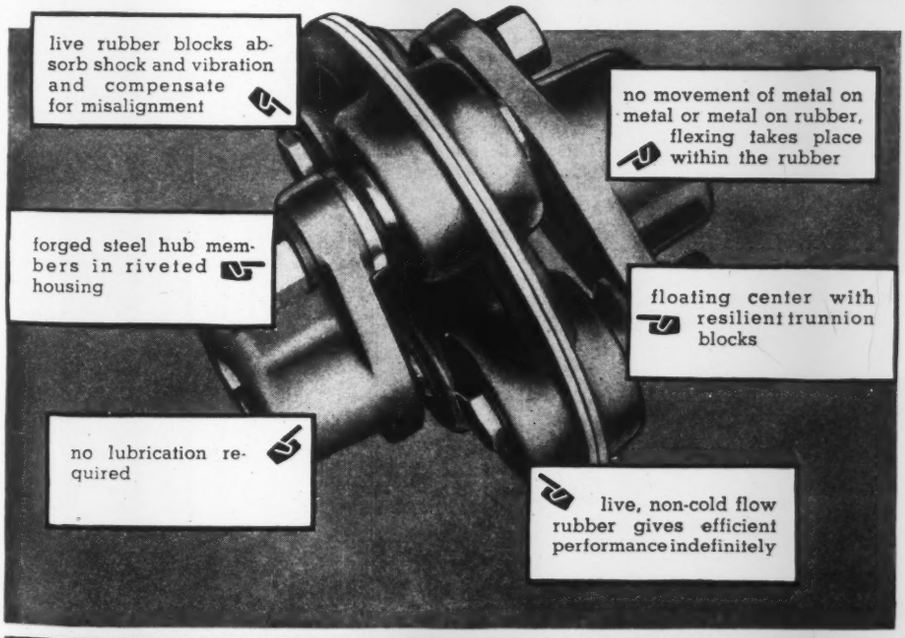
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